DEVELOPMENT OF MANAGEMENT PRACTICES AGAINST TOMATO FRUIT BORER, *Helicoverpa armigera* (Hubner) AND QUANTIFICATION OF RESIDUE OF CYPERMETHRIN AND CHLORPYRIFOS IN TOMATO

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BY
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CERTIFICATE

This is to certify that the thesis entitled, *“INFLUENCE OF FERTILIZER DOSE AND IRRIGATION ON THE GROWTH AND YIELD OF SOYBEAN (Glycine max L.)”* submitted to the Faculty of Agriculture, Sher-e-Bangla Agricultural University, Dhaka in partial fulfilment of the requirements for the degree of MASTER OF SCIENCE in AGRONOMY, embodies the result of a piece of bona fide research work carried out by Yasmin, Registration No. 07-02577 under my supervision and my guidance. No part of the thesis has been submitted for any other degree or diploma.

I further certify that such help or source of information, as has been availed of during the course of this investigation has duly been acknowledged.

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ABSTRACT

The experiments were conducted in the experimental field of Sher-e-Bangla Agricultural University, Dhaka and Pesticide Analytical Laboratory, Entomology Division, BARI, Joydebpur, Gazipur during the period of November 2007 to May 2008 to evaluate the efficacy of some management practices against tomato fruit borer and residue level of insecticide in Tomato. Considering the effects of different management practices applied against tomato fruit borer at early, mid and late fruiting stages, the level of infestation followed more or less similar trend for both by number and by weight of tomato but at late stage the rate infestation by fruit borer was a little bit higher. Among the treatments T_3 (Comprising Ripcord 10 EC @ 1 ml/L of water + Neem seed kernel (20 g /L) at 7 days interval + Mechanical) performed maximum number and weight of healthy fruit/plant and minimum number and weight of infested fruit. The lowest percent fruit infestation by number and by weight was also recorded in T_3 whereas in T_6 (Untreated control treatment) the situation is totally overturned in this trial. In considering the economic analysis of the different treatments in controlling tomato fruit borer, the highest cost benefit ratio (4.55) was recorded in the treatment T_3 (Consisting Ripcord 10 EC @ 1 ml/L of water+Neem seed kernel (20 g /L) at 7 days interval+Mechanical).On the other hand, the minimum cost benefit ratio (1.08) was recorded in treatment T_2. But no management cost was required for T_6 treatment (Untreated control). The residue of the insecticide Cypermethrin (0.031 ppm) was detected in the sample up to 5 Days after spray (DAS) and the quantities were over MRL up to 3 DAS. Chlorpyrifos residue 0.26 ppm was detected in the sample up to 7 DAS of which up to 5 DAS the quantity of residue were above MRL.

CHAPTER 1
INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) is one of the most popular and important vegetable grown in Bangladesh during rabi season as well as in many countries around the world. It belongs to the family Solanaceae. The top ranks next to potato in the world vegetable production (FAO, 1997) and top of the list of canned vegetables (Chowdhury, 1979). It cultivated in all most all home gardens and also in the field due to its adaptability to wide range of soil and climate (Bose and Som, 1990). It is a nutritious and delicious vegetable used in salads, soups and processed into stable products like ketchup, sauce, marmalade, chutney and juice paste, powder and other products.

In Bangladesh, Tomato yield is not satisfactory enough comparison other tomato growing countries of the world (Aditya *et al.*, 1997). The cultivated area of tomato in Bangladesh was 15,574 hectares with an annual (2005-2006) production of 105,000 tons and the average production was about 6.78 ton per hectare (BBS, 2006). Different limiting factors are responsible for the low yield of tomato in Bangladesh. Among them the attack of insect pest from seeding to fruiting stage is the important factor for low yield of tomato because all parts of the plant including leaves, stems, flowers and fruits are subjected to attack.

The tomato plant is attacked by different species of insect pests such as white fly, Aphid and leaf miner in Bangladesh. Among them tomato fruit borer, *Helicoverpa armigera* (Hubner) is one of the serious pest. It has been reported to causes damage to extent to about 50-60 percent fruits (Singh and Singh, 1977). Data revealed that damage by this pest might be up to 85-93% (Tewari, 1985). Due to severe infestation, fruit as well as seed maturation hampered greatly and the viability of the seeds are reduced.

With the ever increasing world population demand for food and the intensified drive for food production call for the greater use of agrochemicals is emphasized. The use of insecticides has become indispensable in increasing vegetable crop production because of its rapid effect, ease of application and availability.

Though the tomato fruit borer is major pest in status, the management of this pest through non-chemical tactics including cultural, mechanical, and biological and host plant resistance etc. undertaken by the researcher throughout the world is limited. Generally the farmers of Bangladesh control this pest by the application of chemical insecticides because the use of chemical insecticides is regarded to be most useful measure to combat this pest. In Bangladesh it was reported that Cypermethrin, Deltamethrin, Fenvalerate and Quinalphos @ 1.5 ml/L of water gave the better result in controlling tomato fruit borer (Alam, 2004). But indiscriminate use of insecticide has not only complicated the management but also created several adverse effects such as pest resistance, outbreak of secondary pests (Hagen and Franz, 1973), health hazards (Bhaduri *et al.*, 1989) and environmental pollution (Kavadia *et al.*, 1984; Desmarchelier, 1985; Devi *et al.*, 1986; (Fishwick, 1988), The sole reliance on the application of insecticides has shown many side effects and limitations (Luckman and Metcalf, 1975).

Maclntyre *et al.* (1989) reported that low level exposure of food products containing insecticide residues to consumers over time might cause cancer, teratogenesis, genetic damage and suppression of the immune system. Pesticide residue in food has become a consumer safety issue and the consumer has the right to know how much pesticide get incorporated in the food he eats. The detection, identification and quantification of pesticide in the food we eat are a problem of increasing public interest.

Modern pesticide residue analysis in developed countries is focusing more and, more on subtle problems, such as looking for very low concentrations of pesticides in the environment. For this complicated and expensive equipments are being used (gas chromatography, high performance liquid chromatography, mass spectrometry).

To assure safety of the consumers, many of the developed countries have set Maximum Residue Limit (MRL) based on the Acceptable Daily Intake (ADI) and Potential Daily Intake (PDI) (Maclntyre *et al.*, 1989) that should not be exceeded for a food item. In Bangladesh context, since harvesting and selling of tomato are done without bothering for the postharvest interval of insecticide use, insecticide residue levels in tomato would mostly be above MRL.

From the above discussion it is very clear that hazards by the indiscriminate insecticide application practices. So, comparing with the international response for the safe uses of insecticides and insecticide use practices by our farmers, it is very essential to establish a residue analysis program in our country.

Therefore, the present study was under taken to fulfill the following objectives:

1. To evaluate the extend of damage by the tomato fruit borer against some management practices in tomato
2. To explore the effective technique(s) among different management practices against tomato fruit borer.
3. To quantify the residue of Cypermethrin and Chlorpyrifos in tomato.

CHAPTER 2
REVIEW OF LITERATURE

Tomato fruit borer is the most important insect pest of tomato in Bangladesh. Studies on different aspects of the tomato fruit borer, *Helicoverpa armigera* and abundance of this pest have been done elsewhere but a few of them is related to the present study.

2.1 General information of tomato fruit borer

2.1.1. Nomenclature

Tomato fruit borer, *Helicoverpa armigera* (Hub.) is a polyphagous insect, belonging to the family Noctuidae of the order Lepidoptera. There are several genera under this family and the genus *Helicoverpa* contains several numbers of species, including *Helicoverpa armigera,* which is the serious pest of tomato (Mishra and Mishra, 1996)

2.1.2 Origin and distribution

Tomato fruit borer is a versatile and widely distributed polyphagous insect. Beside Bangladesh, this pest occurs in Southern Europe, probably the whole of Africa, the Middle East, India, Central and South East Asia to Japan, the Philippines, Indonesia, New Guinea, the eastern part of Australia, New Zealand and a number of pacific islands except for desert and very humid region (Singh, 1972).

2.1.3 Host range of tomato fruit borer

A wide range of host crop plants occurs including cotton, tobacco, maize, sorghum, pennisetum, sunflower, various legumes, citrus, okra and other horticultural crops. Wild plants considered important include species of Euphorbiaceae, Amaranthaceae, Mlalvaceae, Solanaceae, Compositae, Portutacaceae, Convolvulaceae but many other plant families are reported to be the host (Jiirgen *et al*,. 1977).

2.1.4 Life history of tomato fruit borer

2.1.4.1 Egg

Eggs are 0.4-0.5 mm in diameter, nearly spherical with flattened base, glistering yellowish-white in colour, changing to dark brown prior to hatching.

2.1.4.2. Larva

The fully grown larva is about 40 mm in length general colour varies from almost black, brown or green to pale yellow or pink and is characterized by having a dark band along the back to each side of which there is a pale band. The larval period varies from 15-35 days.

2.1.4.3. Pupa

The light brown pupa is about 22 mm in length, living in the soil.

2.1.4.4. Adult

Stout bodied moth has a wing span of 40 mm. general color varies from dull yellow or olive grey to brown with little distinctive marking. The moths become sexually mature mate about four days after emergence from the pupae having fed from the nectars of plants. The moth is only active at night and lays eggs singly on the plant. On hatching, the larva normally eats some or all eggs shell before feeding on the plant.

The larvae of this pest bore circular holes and thrust only a part of their body inside the fruit and eat the contents (Plate-1). If the fruit is bigger in size, it is only partly damaged by the caterpillar but later it is invariably invaded by fungi, bacteria and spoiled completely. A small-darkened partially healed hole at the base of the fruit pedicle is evident (Plate-2). The inside of the fruit has a watery cavity that contains frass and decay. Tomatoes ripen early but not usually consumable and marketable (Husain *et al.* 1998).

The review of literature in terms ‘Development of management practice against tomato fruit borer and quantification of residue of cypermethrin and chlorpyrifos’ were cited below under the followings.

2.2 Management of tomato fruit borer

2.2.1 Cultural control

Cultural control measures are important in minimizing injuries and protesting the crop and should be considered in any integrated control program. Sometimes a slight population reduction brought about by cultural practices delays build up to damaging level. The following cultural practices are to be taken against tomato fruit borer. These are mainly sanitation, rotation, tillage, pruning and defoliation and time of planting.

Plate 1. Tomato fruit borer on tomato

Plate 2. Infested fruit by tomato fruit borer

Sundeep and Kaur (2000) conducted an experiment on the economics of controlling *H. armigera* through suitable cultivars (Punjab Kesri, Punjab Chhuhara, Punjab Tropic and Hybrid Naveen) and cultural practices in tomato for two years (1993-94) at Punjab Agricultural University, Ludhiana, Punjab, India. The cumulative fruit damage and fruit yield were invariably lower in the late transplanted crop. The fruit damage was significantly lower in early maturing and small fruited cultivars Punjab Kesri followed by hybrid Naveen. The fruit yields were however, significantly higher in longer duration and medium fruited hybrid Naveen followed by the variety Punjab Kesri. The returns were highest in early transplanted Naveen followed by late transplanted Naveen and early transplanted Punjab Kesri.

Patil *et al* (1997) studied to assess the effects of intercropping various vegetables with tomatoes on the infestation of tomato fruit borer (TFB), *Helicoverpa armigera* in Karnataka, India, during the kharif season of 1995. No insecticides were used during the course of the experiment. The greatest infestation of TFB (5.6%) was noticed in tomatoes intercropped with snap beans *(Phaseolus vulgaris).* The lowest infestation (3.4%) was observed in tomatoes intercropped with radishes *(Raphanus sativus).* The TFB infestation levels in tomatoes grown alone, tomatoes intercropped with coriander and onion was 4.5%, 4.2% and 4.7%, respectively. The greatest reduction in marketable yields of tomatoes was observed in tomatoes intercropped with snap beans followed by tomatoes intercropped with onions. The greatest marketable yields were observed in tomatoes intercropped with radishes. Total TFB infestation ranged from 17.0% in treatments where radishes were grown as an intercrop, to 28.2% in plots where snap beans were grown intercropped with tomatoes.

2.2.2 Mechanical control

Mechanical control comprising removal of infested fruits is a safe and cheap control technique. It was found that the larvae of this insect can be controlled successfully by this methods following every alternate day during marble size tomato to before ripen period. Report revealed that about 75% control is possible only by this method. But it could be possible to get better result by mechanical method + spraying of botanical pesticides (Nazim, *et al.,* 2002).

2.2.3 Botanical control

Sundarajan (2002) screened methanol extracts of selected plants namely *Anisomeles* *malabarica, Ocimum canum [0. americana], O. basilicum, Euphorbia hirta, E. heterophylla, Vitex negundo, Tagetes indica and Parthenium hysterophorus* for their insecticidal activity against the fourth instar larvae of *H. armigera* by applying dipping method of the leaf extracts at various concentrations (0.25, 0.5, 1.0, 1.5 and 20) on young tomato leaves. The larval mortality of more than 50% has been recorded for all the plant extracts in 2 percent test concentration (48 h) except *E. heterophylla* which recorded 47.3 per cent mortality in 2 percent concentration. Among the plant extracts tested *V. negundo is* found to show higher rate of mortality (82.5%) at 2 percent concentration.

Kulat *et al.* (2001) conducted an experiment on extracts of some indigenous plant materials, which are claimed important as pest control like seed kernels of neem, *Azadiracta indica, Pongamia glabra [P. pinnata],* leaves of tobacco, *Nicotiana tahacaam* and indiara, a neem based herbal product, against *H. armigera* on chickpea cv. I.C.C.V.5 for its management in Rabi seasons of 1993-96 at College of Agriculture, Nagpur, Maharashtra, India. The results revealed that the crop treated with the leaf extract of *N. tabacum* and seed extract of *P. glabra* (5%) and indiara (1%) and neem seed kernel extract (5%) exhibited low level of population built up compared to control.

Ju *et al.* (2000) tested six desert plants chosen to study their toxicity and effects on the growth and metamorphosis of the insect pest, *Helicoverpa armigera.* An artificial diet containing 5% aqueous extracts of *Cynanchum auriculatum* or *Peganum harmala* var. multisecta showed strong toxicity to the larvae and caused mortality of 100% and 55%, respectively. These two extracts at the same dosage also significantly affected metamorphosis of the insect. An artificial diet containing 1% aqueous extracts of *C. auriculatum* or 5% aqueous extracts of *P. harmala* resulted in mortality of 85% and 55%, respectively, and a zero emergence rate. Tests of extracts of *C. auriculatum* made at different pHs showed that the pH 3 and pH 10 portions of the extracts affected the larvae growth significantly. The other plant species tested were *Euphorbia helioscopia, Sophora alopecuroides, Peganum nigellastrum* and *Thermopsis lanceolata;* extracts of these species caused either much lower mortality of *K armigera* or zero mortality *(E. helioscopia).*

Sundarajan and Kumuthakalavalli (2000) tested Petroleum ether extracts of the leaves of *Gnidia glauca* Gilg., *Leucas aspera* Link., and *Toddalia asiatica* Lam. against sixth instar larvae *of Helicoverpa armigera* (Hubner.) at 0.2, 0.4, 0.6, 0.8 and 1.0% by applying to bhendi (okra) slices. After 24 hr, percentage mortality, EC50 and EC90 were calculated. Total mortality was recorded in the treatment with 0.8% of the extract of *G. glauca.* Of the three leaf extracts used, *G. glauca* showed an EC50 of 0.31%.

Botanical pesticides are becoming popular day by day. Now a days these are using against many insects. It was found that Lepidopteran insect is possible to control by botanical substances. Weekly spray application of the extract of neem seed kernel has been found to be effective against *Helicoverpa armigera* (Karim, 1994).

2.2.4 Insecticidal control

The evolution of synthetic organic pesticides is a significant event of the twentieth century. In fact, the discovery of the insecticidal properties of DDT in 1939 followed by a gradual but rapid introduction of other members of the organochlorine, organophosphorous, carbamate and pyrethroid groups along with compounds with herbicidal and fungicidal properties in the second generation organic pesticides was probably the most revolutionary development in the history of pest control.

The synthetic organic pesticides introduced from the Second World War time were soon recognized as wonder pest control chemicals and their increasing uses in the post-war world have significantly contributed in the well being of the mankind. Acute and chronic toxic effects of pesticides in animals are the results of interference with well established bio-chemical process (Hassall, 1990).

Before introducing the synthetic insecticide, farmers were habituated with traditional methods of pest management. At present different types of pest management methods such as mechanical, biological, chemical and integrated pest management (IPM) are followed which are improved with modern technologies. Among the different methods chemical has residual effect.

In Bangladesh, it was reported that cypermethrin, deltamethrin, fenvalerate and quinalphos @ 1.5 ml/L of water gave the better result (Alam, 2004).

In India, it was also found that tomato plants (line CV S-22) were sprayed with various insecticides 4 times at 2-week intervals from the onset of flowering. Cypermethrin (30g a.i./ha), Deltamethrin (l0g a.i./ha) and permethrin (100g a.i./ha) gave good control of *H. armigera* (Divakar *et al*. 1987).

Mehta *et al* (2000) carried out an experiment on the management of tomato fruit borer, *Heliocoverpa armigera* (Hubner) with nine insecticidal treatments for 3 season during 1995-1997 at Palampur (Himachal Pradesh, India). Over all effectiveness expressed as reduction in borer damaged tomato fruits and increase in fruit yield indicated the superiority of deltamethrin alone or in combination all through the experimentation. Application of deltamethrin resulted in lowest fruit damage (4.27%) followed by cypermethrin (8.98) and acephate (9.16%). Among the biopesticides tested, B.t. treated plots had lowest fruit infestation (10.68%) as compared to HaNPV (11.95%) and azadirachtin (14.68%). A mixture of deltamethrin + B.t. application reveled a fruit damage of 5.58 percent while untreated control had 24.2 percent fruit damage. The mean fruit yield was highest in deltamethrin + B.t. treated plots followed by deltamethrin, acephate and cypermethrin.

Of several insecticides compared against *H. armigera*, quinalphos at 0.05% was the most effective (Tewari, 1985).

Patel *et al.* (1991) conducted field studies in Gujarat, India to determine an effective and economical insecticide formulation to control the noctuid *Helicoverpa armigera* on tomatoes, endosulfan (0.07%) spray gave the highest cost-benefit ratio (1: 5.26) followed by endosulfan (2%) dust (1: 4.9). Results are also given for monocrotophos, quinalphos and malathion.

Jitender *et al.* (1999) conducted an experiment on the estimation of avoidable yield loss due to fruit borer, *Helicoverpa armigera* in tomato (cv. Roma) planted at three dates (first week each of April, May and June), during 1993 and 1994, in Kullu valley, Himachal Pradesh, India, showed that in crop transplanted in the first week of April yield loss to the extent of 105.29, 76.02 and 57.02% could be avoided by giving three sprays of acephate (0.05%), fenvalerate (0.01%) and endosulfan (0.05%), respectively. In crop transplanted in the first week of May yield loss of 32.64, 28.04 and 18.50% could be avoided as a result of sprays of respective insecticides. Whereas in June-transplanted crop, 2 sprays each of acephate, fenvalerate and endosulfan helped in avoiding 25.03, 13.91 and 11.76% yield loss, respectively. Irrespective of dates of transplanting, the average yield loss to the extent of 49.27, 36.54 and 26.59% could be avoided by sprays of acephate, fenvalerate and endosulfan. The average net return per rupee invested worked out to be Rs 14 for acephate, Rs 13.18 for fenvalerate and Rs 7.80 for endosulfan sprays.

Pinto *et al.* (1997) reported in Sicily that when the population exceeds the economic threshold, control can be effected using systemic products such as phosphoric esters (acephate, methomyl, dimethoate) or synthetic pyrethroids (alphamethrin [alpha-cypermethrin], deltamethrin); the latter must be used once only so as not to favour the build-up of mites. Agronomic methods of defence may also be used, such as weeding to kill the pupae, deep ploughing of adjacent uncultivated areas during the period of oviposition, and elimination of weeds on which the females oviposit.

Walunj *et al.* (1999) conducted field trials at Ahemadnagar, Maharashtra, India to asses the efficacy of profenofos at 0.5kg/ha, profenofos + cypermethrin at 0.33-0.44 kg, lufenuron at 0.33kg, dichlorvos at 0.76 kg and cypermethrin at 0.05 kg for control of *Helicoverpa armigera* in tomatoes cv. Namdhari Hybrid 815. Products were applied 5 times at 15 day intervals. The results indicated that fruit damage was reduced in all treatments. Lowest infestations and highest yields of marketable fruits (7.388t/ha) were recorded with the 0.44kg profenofos + cypermethrin treatment.

Dilbagh *et al.* (1990) conducted field trials in Punjab, India and revealed that fenvalerate, permethrin and cypermethrin applied at 50g a.i./ha, or decamethrin [deltamethrin] applied at 20g a.i./ha gave equal or better control of the noctuid *Helicoverpa armigera* than carbaryl or endosulfan applied at 1000 and 700g a.i./ha, respectively. Yields were higher when synthetic pyrethroids were used.

Ogunwolu (1989) studied the effects of damage caused by *Helicoverpa armigera* on yields of tomato transplanted at different times in Nigeria in 1985-86 by treatment with some insecticides against this pest. Fruit damage was highly but negatively correlated with the number, weight and yield of harvested fruits. Fruit damage was significantly reduced and yield increased by spraying, showing that serious damage was caused by *H. armigera.* Cypermethrin suppressed fruit damage by 70.4 and 52.2% in 1985 and 1986 and increased yield by 115.0 and 67.6%, respectively.

2.2.5 Integrated Pest Management (IPM)

Brar *et al.* (2003) carried out a study to determine the efficacy of *Trichogramma pretiosum*

(5 releases weekly at 50000 per ha), *H. armigera* nuclear polyhedrosis virus (Ha NPV; 2,3 or 5 sprays at 7, 10 or 15-day intervals at 1.5 x 1012 polyhedral occlusion bodies per ha) and /or endosulfan (3 sprays at 15 day intervals at 700 g/ha) for the management of tomato fruit borer *(H. armigera)* in Punjab, India, during 1999-2002. In all study years, egg parasitism was high (36.32-61.00%) in plots where *T. pretiosum* was released. The mean egg parasitism was highest in the plot treated with *T. pretiosum* alone (49.33). The mean egg parasitism was 7.45 and 14.85% in the endosulfan-treated and control plots respectively. Fruit damage was highest during 1999-2000. Among all treatments, treatment with *T. pretiosum* + HaNPV + endosulfan resulted in the lowest fruit damage (13.07%) and the highest mean yield (243.86 q/ha). The control treatment had the borer incidence and fruit damage, and the lowest yield 163.31 q/ha) among all treatments. The yield in endosulfan alone was 209.31q/ha, which was significantly superior to three HaNPV sprays (184.15q/ha). It is concluded that the treatment combination *T. pretiosum* + HaNPV + endosulfan was most effective for *H, armigera* control.

Gopal *et al.* (1997) conducted field trials in India to determine the efficacy of insecticides (endosulfan and diflubenzurun), neem products and nuclear polyhedrosis virus (NPV) alone or in combination for the control of fruit borer, *Helicoverpa armigera,* on tomatoes. Neem seed kernel extract (NSKE) 3% + endosulfan 0.035% + NPV at 250 larval equivalents (LE) ha^{-1} applied 3 times at 45, 55 and 65 days after planting gave the highest larval mortality, reduced fruit damage, and the highest fruit yield, followed by neem oil 3% + endosulfan 0.035% + NPV at 250LE ha^{-1}, and endosulfan 0.07% gave the highest cost:benefit ratio, followed by NSKE 3% + NPV at 250 LE ha^{-1} and NSKE 3% + endosulfan 0.035% +NPV at 250 LE ha^{-1}.

Sundararajan (2001) carried out toxicological studies to evaluate the effect of leaf methanolic extracts of 5 indigenous plant materials namely, *Abutilon indicum, Achyranthes aspera*, *Ailanthus excelsa*, *Alstonia venenata* and *Azima tetracantha* against *Helicoverpa armigera.* Twenty healthy larvae collected from a tomato field were released into plastic containers containing tomato leaves treated with each of the plant extracts. The larval mortality was recorded 48 h after the release. Larval mortality on tomato leaves treated with *Azima tetracantha, Achyranthes aspera, Abutilon indicm, Ailanthus excelsa* and *Alstonia venenata* averaged 51, 58, 62, 67 and 73%, respectively.

Ganguly and Dubey (1998) evaluated a number of insectisidal treatments against *Helicoverpa armigera* on tomato (variety Pusa Ruby) in Madhya Pradesh, India, during the rabi season 1995-1996, *Helicoverpa* nuclear polyhedrosis virus (250 larval equivalents) + endosulfan at 0.07% was the most effective, resulting in a 47.96% increase in yield and 32.52% avaidable losses.

Karabhantanal *et al.* (2005) carried out an investigation during 2001 and 2002 during kharif seasons in Karnataka, India, to evaluate different Integrated Pest management (IPM) modules against tomato fruit borer, *Helicoverpa armigera.* The results revealed that the IPM module consisting of trap crop (15 row of tomato: 1 row marigold) + *Trichoghamma pretiosum* (45000%/ha)-NSKE (5%)- HaNPV (250LE/ha) - endosulfan 35 EC (1250m1/ha) was significantly superior over the rest of the modules tested in restricting the larval population (100% after the fourth spray). As a result of which, the lowest fruit damage (11.87%), highest marketable fruit yield (224.56q/ha) and additional net profit (Rs. 22915/ha was observed in this module, but was comparable with the recommended package of practice and IPM module consisting of *Nomuraea rilevi* (2.0 x1011 conidia/ha) NSKE (5%) HaNPV (250LE/ha) - endosulfan 35EC (1250m1/ha).

Sivaprakasam (1998) conducted field studies in Tamil Nadu, India, during July - December 1992 and revealed that nuclear polyhedrosis virus + endosulfan (260 g) and endosulfan (520 g) sprays gave an effective level of control of *Helicoverpa armigera* infesting the PKM 1 variety of tomato.

Pokharkar *et al.* (1999) conducted an experiment during the spring seasons of 1992 and 1993 in Hisar, Haryana, India, to study the effectiveness of nuclear polyhedrosis virus alone and in combination with endosulfan in the integrated control of *Helicoverpa armigera* on tomato *(Lycopersicon esculentum).* Three sprays of endosulfan 0.07% at 10-day-intervals starting from 50% flowering of the crop proved to be effective. Application of *Helicoverpa armigera* nuclear polyhedrosis virus at 700 LE (larval equivalent)/ha gave better protection to tomatoes from *H. armigera* resulting in a 98.25-100% reduction in the larval population, 6.89% mean fruit damage, 57.49 kg/plot (4 m X 5 m) mean total yield and 53.64 kg/plot mean marketable yield, and it was as effective as the *Helicoverpa armigera* nuclear polyhedrosis virus at the 500 LE/ha dose. Sequential application with the first spray of endosulfan 0.07% followed by 2 sprays of *Helicoverpa armigera* nuclear polyhedrosis virus at 250 LE/ha greatly reduced the larval population and was comparable with 3 applications of endosulfan 0.07% applied alone.

Satpathy *et al.* (1999) conducted a field trials in Varanasi, Uttar Pradesh, India, nuclear polyhedrosis virus applied with half the recommended dose of endosulfan (350 g a.i./ha) gave effective control of *H. armigera* on tomato. Application of crude NPV at 300 LE was also effective.

Ganguli *et al.* (1997) carried out field trials in winter 1994-95 at Raipur, Madhya Pradesh, India, to study the effectiveness of NPV (250 LE (larval equivalents)/ha) applied at time of pest appearance + endosulfan (0.035 or 0.070%, 7 or 15 days after NPV) against *Helicoverpa armigera* incidence and yield of tomato cv. Pusa Ruby. Other treatments included 2 consecutive sprays of NPV, a single spray of NPV or endosulfan, and a control (no treatment). Fruit damage at the time of first picking ranged from 20.26 to 41.34%, with the least damage occurring on plots treated with NPV followed by endosulfan. Tomato yields were significantly greater on plots treated with NPV followed 7 days later by 0.07% endosulfan (178.40 Q/ha (17.84 t/ha)) than on any other plots. It is concluded that spraying with NPV (250 LE/ha) at the time of appearance of the pest, followed 7 days later by endosulfan at 0.035 or 0.070%, will protect the tomato crop from *H. armigera.*

Pandey *et al.* (1997) conducted a series of experiments in 1993-96 in the Western Hills, Nepal, to understand the pest dynamics and to develop integrated pest management (IPM) technologies against tomato fruit borer *Helicoverpa armigera.* Monitoring of *H. armigera* for several seasons across the agro-ecological zones indicated that March-April is the peak activity period of the moth. The period coincides with the flowering/fruiting season of tomato and the pest causes severe yield losses. Tomato cv. Roma and local landraces collected from Kholakhet, Parbat, were found to be less preferred for egg laying by this pest. The naturally occurring egg parasitoid *Trichogramma chilonis* was more abundant in the river basins than in the low-middle range hills. Within the river basins, activity of the parasitoid was low early in the season. There is scope for augmentative release of laboratory reared parasitoids for the management of this pest. Nuclear polyhedrosis viruses, although reported to be useful against *H. armigera* elsewhere, was not very promising under these conditions.

2.3 Pesticide Residue Tolerances (MRLs, ADI)

ADI values of a number of pesticides have been published jointly by the World Health Organization. (WHO) and the Food and Agriculture Organization (FAO) of the United Nations. Safety factors, ADIs and the aspects of the evaluations of health hazards have been reviewed by Sharratt (1977) and Vettorazzi (1977). FAO and WHO through their Codex Committee on Pesticide Residues (CCPR) have worked out international pesticide residue tolerances which are intended as guidelines for world-wide national legislation. These- tolerances (maximum residue limits, MRLs), are set according to the philosophy that no crop should be treated with pesticides at higher application rates than necessary (good agricultural practice). Essentially, the MRL for a named pesticide is the highest concentration that may be present on a commodity at the time of marketing.

2.4 Review of Insecticide Residues

Khan (2005) conducted an experiment during crop season 2000, the initial residue cypermethrin obtained by HPTLC were 0.67 mg/kg. After 10 days, it was dissipated to 0.10 mg/kg, thus representing a loss of 85%. The samples did not contain any detectable residues 15 days after application. However, analysis by HPLC gave initial residues of 0.86 mg/kg which were dissipated to 0.09 mg/kg in 15 days. The year 2001, the initial residues of cypermethrin on tomato fruits by HPTLC methods were found to be 0.87 mg/kg which were reduced to 0.10 mg/kg after 15 days. Half-life values of cypermethrin in tomato fruits varied from 3.63 to 4.50 and 5.90 to 6.84 days during crop season 2000 and 2001, respectively. The withholding periods from 6.82 to 8.59 days for cypermethrin during 2000. In the year 2001, the periods were 11.59 to 13.54 days for cypermethrin. The initial residue of 2.70 mg of chlorpyrifos/kg by HPLC dissipated to 0.10 mg/kg 21 days after application by the HPTLC method, the initial residue of 2.61 mg/kg degraded to 1.02 mg/kg 14 days after application. No residues were detected in the fruits 21 days after application. During 2001, residues of chlorpyrifos in apples required 6.78 to 14.82 days to fall below the recommended tolerance levels, whereas in year 2002, these insecticides required 7.20 – 7.96 days to decline below the tolerance level. The half-life values of chlorpyrifos ranged from 4.85 to 11.57 days during 2001. The half-life valuse of these insecticides were 3.10 – 3.42 and 5.02 – 5.57 days in 2002. In 2002, initial residues of chlorpyrifos obtained by HPLC were 4.26 mg/kg, the residues persisted beyond 21 days, however, chlorpyrifos residues in 21 days samples could not be detected by HPTLC method.

The multi-residue method was based on acetone extraction, partitioning with n-hexane/methylene chloride followed by gel permeation chromatography (GPC) clean-up and determination by capillary GC using conventional detectors such as ECD; FPD, NPD and FID. A multi residue method based on ethyl acetate extraction followed by GPC clean-up and GC determination using conventional detectors. This is still the main method used for the analysis of fruit and vegetables in Sweden (Akterblom, 1995).

A study was carried out in Ludhiana, India to determine the residues of Permethrin applied for the control of *Leucinodes orbonalis* on eggplant fruit. The compound was sprayed at a rate of 50g a.i/ha at fortnightly intervals. Initial deposits on fruit range from 1.3 to 0.7 mg/kg and maximum residue level 1, 2, 3 and 10 days after spraying was 0.34, 0.2, 0.11 and 0.07 mg/kg respectively. The half life on insecticides on fruits ranged from 2.1 to 3.0 days. The trans-isomers of Permethrin degraded slightly faster than the cis-isomers in leaves and fruits. A 1-day waiting period is recommended for consumption of fruits (Singh and Kalra, 1989).

Frank *et al*. (1990) studied that organophosphorus, synthetic pyrethroid and N-methyl carbamate insecticides and dithiocarbamate, dicarboximide and organochlorine fungicides. The estimation was done in 433 composite vegetable samples representing 16 commodities collected between 1986 and 1988 from farm deliveries to the market place Ontario, Canada. Commodities tested included eggplant, asparagus, carrots celery, cole crops, cucumbers, lettuce, onions, peppers, potatoes, radishes and tomatoes. In 64% of samples, no pesticide residues were identified to the limits of detection which ranged from 0.005 to 0.05 mg/kg. These involved Diazinon and Parathion on celery and Chlarothalonil on peppers. Whereas, some commodities had no detectable residues.

According to Singh and Karla (1992) Gas-liquid chromatography determination of Cypermethrin residues in tomato fruits, leaves and soil samples drawn at 0,1,2,5 and 10 days after treatment were analyzed. The analytical process was done by silica gel column clean-up and 63 Ni gas liquid chromatographic estimation. The minimum limits of cis-permethrin and trans-cypermethrin were 0.008 and 0.006 mg/kg. Initial deposit of Cypermethrin on fruit and was observed 0.73 mg/kg after eighty sprays at 50g/kg a.i/ha application rate, which declined to 0.61 mg/kg one day after treatment and then became

0.08 mg/kg after 10 days.

FAO/WHO (1993) reported that the trials were conducted in Canada (4), France (1) and the USA (23) using EC, WP and GR formulations. In the US trails a GR or EC pre-planting application at 4.4 Kg a.i/ha was followed by five foliar sprays at weekly intervals with WP or EC formulations at the rate of 0.55Kg a.i/ha, the other trials were with granules at 2.25 or 10 kg a.i/ha one month after planting. No residues of Diazinon in potatoes were detectable (<0.01 mg/kg) in any of the harvested samples except in three trials where residues of 0.01 mg/kg were found.

FAO/WHO (1993) reported that the trials were carried out in the Canada (1), the Netherlands (2 indoor) and the USA (68) using EC, WP, SP and GR formulations. In the US trials a pre-planting granules or EC at 4.48 kg a.i/ha was followed by five foliar sprays at weekly intervals with WP or EC formulations at 0.84 kg a.i/ha. Canada reported one treatment with an EC formualtion at a rate of 0.8 Kg a.i/ha and the Netherlands one treatment with an SP formulation at 0.19 kg a.i/ha.ln the indoor trials no residues were detectable (<0.04 mg/kg) three days after application. In the other trials residues of Diazinon in tomatoes ranged from <0.01 to 0.84 mg/kg 1-14 days after the last application.

FAO/WHO (1993) reported that ten rials were carried out in the USA using a granule before planting at 4.48 kg a.i/ha and five foliar sprays at weekly intervals with WP or EC formulations at a rate of 0.56 kg a.i/ha. Residues of Diazinon in peppers 3 to 14 days after the last application ranged from <0.01 to 0.09 mg/kg.

Dethe *et al.* (1995) reported that they were conducted few studies on the residues of commonlyy used pesticides in/on vegetables in India. Detectable levels or residues were observed in 33.3% of.tomatoes (Diazion, Endosulfan, Dimethoate and Monocrotophos), 73.3% of eggplant (Endosulfan, Diazinon, Cypermethrin, Fenvalerate, Quinalphos, Dimethoate and Monocrotophos), 14.3% of okras (Endosulfan), 88.9% of cabbage (Endosulfan, Fenvalerate, Cypermethrin, Dimethoate and Monocrotophos). However, the levels of pesticide residues were lower than the maximum residue limits (MRL) prescribed

Tejada *et al.* (1995) reported that pesticide management survey revealed the crop protection practices of 51 farmers involved in Tomato and okra production in six provinces of Philippines, market basket surveys in Laguna and metro Manila showed some samples of Tomato and okra containing Triaophos, Carbaryl and Deltamethrin residues.

The dissipation of Triazophos and Carbaryl residues in okra and tomato were monitored in both supervised and farmer cooperators field trials. Triazophos residues in okra persisted up to the 7th day while a rapid decline was observed for residue in Tomato. A pre-harvest interval of 5-7 days may be safe for Triazophos use in Tomato Carbaryl degraded rapidly in Tomato and a pre-harvest interval 3ays may be safe. Farmer practice of insecticide usage in eggplants generally showed the use of recommended dosage rates and proper observance of recommended pre-harvest intervals. Washing of Tomato is strongly recommended as it reduces Trizophos residues by 20-90%.

Ahuja *et al*. (1998) reported that cauliflowers, cabbages, tomatoes, brinjal, okras, field beans and cucumbers were monitored for residues of GCH and its isomers, Endosulfan, Dimethoate, Monocrotophos, Quinalphos, Fenvalerate, Cypermethrin. The residues of alpha, beta, tau isomers of HCH, Endosulfan, monocrotophos, Quinalphos, Dimethoate were detected in most of the samples. However, the residues of Monocrotophos on tomatoes, brinjal and okras and those of Carbendazim on French beans were found to persist over the prescribed maximum residue limit values.

In five trials on Broccoli in NewYork, Tennessee, Washington, California at 1.4 kg ai/ha(GAP is 0.1-3.4 kg ai/ha),the residues at 3-5 days PHI varied from 0.02-9.3 mg/kg (FAO/WHO, 1999).

FAO/WHO (1999) reported that in fourteen trials on head cabbage in Wisconsin, Ohio, New York, Florida, Washington, California, Indiana and Texas at 1.4 kg ai/ha (GAP is 0.1-3.4 kg ai/ha), samples with or without the wrapper leaves at 7 days PHI had malathion residues of <0.05(13) and 0.10mg /kg.

In seven trials in Florida, New Jersey, Texas, North Carolina, California and Michigan close to maximum (GAP 2.Okg ai/ha), malathion residues at 3 days PHI were <0.01(4),0.02,0.05 and 0.08 mg/kg and maximum residue level of 0.01 mg /kg.(FAO/WH0,1999).

Five trails were conducted on lima bean in Wisconsin, Florida, Pennsylvania , North Carolina, and five on snap bean in Wisconsin, Oregon New York with aerial applications according to GAP (00.7kg ai/ha). At a PHI of 1 day, the residues were < 0.01, 0.05, 0.12, 0.13, 0.21, 0.41, 0.49, 0.56, 0.71 and 0.90 mg/kg. They were estimated a maximum residues level of 1 mg/kg and STMR of 0.31 mg/kg for beans except broad beans and soyabeans (FAO/WHO, 1999).

In six trails in Wisconsin, New jersey, Florida, Washington, California, Texas at 1.4 kg ai /ha (GAP was 1.2- 2.4 kg ai/ha)residues ranged from < 0.05 to 0.54 mg / kg after 7 days .

Potatoes were treated at 5 times the maximum label rate and harvested on the day of the last application. Residues in whole tubers, granules, wet peel and chips were < 0.01 mg/kg. Malathion was detected only in the dry peel at a level of 0.06mg/kg.

CHAPTER 3

MATERIALS AND METHODS

The experiments were conducted at the experimental fields of Sher-e-Bangla Agricultural University (SAU), Sher-e-Bangla nagar, Dhaka, and in Pesticide Analytical Laboratory, Entomology Division, BARI, Joydebpur, Gazipur.Bangladesh during November 2007 to May 2008 to know the efficacy of some management practices against tomato fruit borer and to determine the residue of cypermethrin and chlorpyrifos in tomato. The materials and methods under the study are given below:

Experiment 1: Development of management practices against tomato fruit borer

Experiment 2: **Quantification of residue of cypermethrin and chlorpyrifos in tomato fruit**

Other details of the experiments are furnished below:

Experiment 1: Development of management practice against tomato fruit borer

The present study on evaluation of some management practices against tomato fruit borer, *Helicoverpa armigera* (Hubner) was under taken and conducted at the experimental field of Sher-e-Bangla Agricultural University, Sher-e-Bangla nagar, Dhaka, during November 2007 to May 2008.

The materials and methods are discussed on the following head and sub headlines:

3.1.1 Location of the experimental field

The experiments was conducted at the experimental farm of Sher-e-Bangla Agricultural University, Dhaka situated at latitude 23^0 46" N and longitude 90^0 23" E with an elevation of 8.45 meter the sea level.

3.1.2 Climate of the experimental area

The experimental area is characterized by subtropical rainfall during the month of November 2007 to May 2008 and scattered rainfall during the rest of the year (Appendix I).

3.1.3 Soil of the experimental field

Soil of the study site was silty clay loam in texture belonging to series (Appendix II).

The area represents the Agro-Ecological Zone of Madhupur tract (AEZ-28) with pH 5.8-6.5, CEC-25.28 (Haider *et al.*, 1991).

3.1.4 Land preparation

The soil was well prepared and good tilth and was ensured for commercial crop production. The target land was divided into 18 equal plots (3 m × 2 m) with plot to plot distance of 0.5 m and block to block distance is 1.0 m. The land of the experimental field was ploughed with a power tiller. Later on the land was ploughed three times followed by laddering to obtain desirable good tilth. The corners of the land were spaded and larger clods were broken into smaller pieces. After ploughing and laddering, all the stubbles and uprooted weeds were removed and then the land was ready. The field layout and design of the experiment were followed immediately after land preparation.

3.1.5 Manure and fertilizer

Recommended manures and fertilizers were applied as follows (Rashid, 2003)

Cow dung	:	10 t ha^{-1}
Urea	:	500 kg ha^{-1}
TSP	:	400 kg ha^{-1}
MP	:	20 kg ha^{-1}

All well decomposed cow dung, TSP and 50% urea and MP were applied at the time of final land preparation. Further application of the rest of urea and MP were applied after 10 days of planting.

3.1.6 Design of experiment and layout

The experiment was laid out in a Randomized Complete Block Design (RCBD) with three replications. The whole area of experimental field was divided into 3 blocks and each block was again divided into 6 unit plots.

3.1.7 Treatments

Comparative effectiveness of the following eight treatments in reducing the tomato fruit borer infestation on tomato (BARI tomato-2) was evaluated:

T_1 = Dursban 20 EC (1.5 ml $liter^{-1}$) at 7 days interval

T_2 = Ripcord 10 EC (1 ml $liter^{-1}$) + Mechanical at 7 days interval

T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval

T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval

T_5 = Mechanical at 7 days interval

T_6 = Control

3.1.8 Collection of seed and seedling raising

The seeds of selected tomato variety BARI-2 (Ratan) were collected from Bangladesh Agricultural Research Institute (BARI), Joydebpur, Gazipur. Before sowing seeds, the germination test was done to ensure 90% germination.. Seeds were then directly sown in the seedbed containing a mixture of equal proportion well decomposed cow dung and loam soil. After sowing seeds, the seedbeds were irrigated regularly. After germination, the seedlings were spayed with water by a hand sprayer. Soil was spaded 3 or 4 days for a week.

3.1.9 Seedling transplanting

The 30 days old healthy seedlings of the selected variety were transplanted on 2nd December, 2007 in the pits of the randomly selected each unit plot assigned for each treatment in the main field.

3.1.10 Cultural practices

After transplanting, a light irrigation was given. Subsequent irrigation was applied in all the plots as and when needed. After 15 days of transplanting a single healthy seedling per pit was allowed to grow discarding the others, propping of each plant by bamboo stick was provided on about 1.0 m height from ground level for additional support and to allow normal creeping. Weeding and mulching in the plot were done, whenever necessary.

3.1.11 Data collection and calculation

For data collection three plants per plot were randomly selected and tagged. Data collection was started at flower initiation up to fruit harvest. The data were recorded on flower and fruit (by number and by weight) infested by tomato fruit borer larvae. All the data were collected at 7 days interval.

3.1.11.1 Percent flower infestation by number

Number of infested flower was counted from total flowers and percent flower infestation was calculated as follows:

$$\% \text{ Flower Infestation} = \frac{\text{Number of the infested flower}}{\text{Total number of flower}} \times 100$$

3.1.11.2. Percent fruit infestation by number

Number of infested fruit was counted from total harvested fruits and percent fruit infestation by number was calculated as follows:

$$\% \text{ Fruit infestation (by number)} = \frac{\text{Number of the infested fruit}}{\text{Total number of fruit}} \times 100$$

3.1.11.3. Percent fruit infestation by weight

Infested fruits were weighted from total harvested fruits and percent fruit infestation was calculated as follows:

$$\% \text{ Fruit infestation (weight)} = \frac{\text{Weight of the infested fruit}}{\text{Total f fruit weight}} \times 100$$

3.1.11.4 Percent reduction of fruit over control

The number and weight of infested and total fruit for each treated plot and untreated control plot were recorded and the percent reduction of fruit infestation by number and by weight was calculated using the following formula:

$$\% \text{ Infestation reduction over control} = \frac{X_2 - X_1}{X_2} \times 100$$

Where, X_1 = The mean value of the treated plot

X_2 = The mean value of the untreated control plot

3.1.11.5 Percent yield loss

The weight of infested fruits was recorded from the total weight of the harvested fruits for each plot and the percent yield loss was calculated considering the following formula:

$$\% \text{ Yield loss} = = \frac{\text{Average wt. of healthy fruit per plot- Average fruit wt. of per plot}}{\text{Average weight of healthy fruit per plot}} \times 100$$

3.1.12 Statistical analysis

Data statistically analyzed by randomized complete block design through MSTAT-C software and Duncan's multiple range tests was used to determine the levels of significant differences among treatments with regards to studied tomato fruit borer infestation.

Experiment 2: Quantification of residue of cypermethrin and chlorpyrifos in tomato fruit

The residue analysis was done at Pesticide Analytical Laboratory, Entomology Division, BARI, Joydebpur, Gazipur. GC-2010 was used to analyses the residue level in tomato fruit samples. The Standard Chlorpyrifos and Cypermethrin were obtained from Sigma-Aldrich Laborchemikalien, Gmbh P O Box-100262 D-30918, Seelze, Germany via Bangladesh Scientific Pvt. ltd. Dhaka, Bangladesh. Standards of all pesticides contained > 99.6% purity. The formulated products of those were Dursban 20 EC and Ripcord 10 EC, respectively. The purity of all formulated insecticides were tested in the laboratory and found to be 100%.

3.2.1 Field experiment for residue analysis

3.2.1.1 Application of Chlorpyrifos and Cypermethrin

In 3 liters of water 5 ml of Chlorpyrifos (Dursban 20 EC) was mixed and 3 ml of Cypermethrin (Ripcord 10 EC) was mixed with another 3 litres of water. Both the solution was sprayed by Knapsack Sprayer at 7 days interval.

3.2.1.2 Sampling

In both cases (Cypermethrin and Chlorpyrifos) tomato fruit samples were taken at 0, 1, 3, 5 and 7 DAS (Days After Spraying). The collected samples were kept in deep freeze.

3.2.1.3 Residue Analysis

The residue analysis was done at Pesticide Analytical Laboratory, Entomology Division, BARI, Joydebpur, Gazipur. GC-2010 was used to analyses the residue level in colledted tomato fruit samples.

3.2.1.4 Apparatus required

(a) GC-2010, Shimadzu corporation, Japan (Plate 3)

(b) Rotavapor, Model: R-210, Switzerland (Plate 4)

(c) Electric balance, Model: AY- 220, Shimadzu Corporation, Japan (Plate 5).

(d) Centrifuge machine, model: Sigma 3k 30, Germany (Plate 6)

(e) Vortex, Model: Maxi max ii, USA (Plate 7)

(f) Homogenizer, Model: Ultraturax, IKA T18 basic, Germany (Plate 8)

(g) Orbital shaker, Model: Rexmed, Sweden (Plate 9)

Plate 3: Gas Chromatograph (GC)

Plate 4: Rotary Vacuum Evaporator

Plate 5: Electric balance

Plate 6: Centrifuge machine

Plate 7: Vortex

Plate 8: Homogenizer

Plate 9: Orbital shaker

In addition to the above instruments the following accessories were also used:

(a) Scissors

(b) Measuring cylinder

(c) Conical flask

(d) Volumetric flask

(e) Tray

(f) Knife

(g) Spatula

(h) Funnel

(i) Test tube

(j) Micro pipette

(k) Aluminum foil

(l) Para film

(m) Glass vial etc.

3.2.2 Sample preparation, extraction and separation

The frozen samples were kept in room temperature for 5-6 hours to make normal. The methodology prescribed by William and George (2005) with necessary modification was adopted for extraction, separation and clean-up of the sample.

Field collected tomato (≥250 g) were taken for extraction. Tomato fruit sample was grounded thoroughly with the meat grinder (Handmixer M-122, Bamix, Switzerland). From this 20 g sub sample was taken into a wide mouth jar. For Cypermethrin, 100 ml of hexane was added to it and incase of Chlorpyrifos, 100 ml of acetone was added to it . Sodium sulphate (Na_2SO_4) was also added with sample until water was removed from the sample. The mixture was then macerated with high-speed homogenizer (Ultraturax, IKA T18 basic, and Germany) for 2 minutes. The homogenized material was then poured into 250 ml conical flask and placed into shaker (Orbital Shaking Incubator, Rexmed, Sweden) for 6 hrs continuous shaking. After shaking, the slurry was filtered through a Buchner funnel with suction. The flask and filter cakes were rinsed with 8-10 ml of acetone/hexane each.

The filtrate then transferred into 250 ml round bottom flask and was dried to 5-7 ml by evaporation using a rotary vacuum evaporator (Plate 3). The concentrated filtrate was then transferred into 500 ml seperatory funnel making 10 ml volume with acetone for Chlorpyrifos and hexane for Cypermethrin. For colour removal, around 20 ml methanol was added with 10 ml filtrate and shaked vigorously for 3-5 minutes. After shaking, the separatory funnel was set on stand and kept undisturbed for 3-5 minutes. Then the clear part of the solution from the bottom of the separatory funnel was collected in vial which was then centrifuged at 12000 rpm for 5 minutes (Laboratory Centrifuges, Sigma-3K30, Germany). After centrifuge, supernatant was collected for injection.

3.2.3 Detection and quantification of Cypermethrin and Chlorpyrifos residue in samples

The concentrated extracts were subjected to analysis by GC-2010 (Shimadzu) with Electron Capture Detector (ECD). The capillary column used was AT-1, length 30m, ID 0.25mm and film thickness 0.25µm. Nitrogen was used as carrier and make up gas in ECD.

Instrument parameters for GC-ECD for the analysis of Cypermethrin were as follows:

[Injection Port SPL]

Injection Mode	: Split	Temperature	: 280^{0}C
Flow Control Mode	: Linear Velocity	Split Ratio	: 10

[Column Oven]

Initial Temperature : 150^{0}C

Column Oven Temperature Program:

Total Program Time: 18.00 min

Rate (^{0}C/min)	Temperature (^{0}C)	Hold Time (min)
-	160	1
10	270	6

[Detector Channel 1 ECD]

Temperature	: 300^{0}C	Stop Time	: 18 min
Current	: 1.00 pA	Makeup Flow	: 30 ml/min

Instrument parameters for GC-ECD for the analysis of Chlorpyrifos were as follows:

[Injection Port SPL]

Injection Mode	: Split	Temperature	: 220^0C
Flow Control Mode	: Linear Velocity	Split Ratio	: 10

[Column Oven]

Temperature : 180^0C

[Detector Channel 1 ECD]

Temperature	: 250^0C	Stop Time	: 12 min
Current	: 1.00 pA	Makeup Flow	: 30 ml/min

Two standard calibration curve (Figure.5-9) were obtained by injecting different concentration of standard of Cypermethrin (Figure.1-4) and Chlorpyrifos(Figure.6-8) solution. The injected volume of supernatant was 1ųl. Each peak was characterized by its retention time. Sample results were quantitated in ppm automatically by the GC software, which represented the concentration of the final volume injected and from this, the actual amount of pesticide residue present in the sample was determined by using the following formula:

Residue in sample (ppm)

$$= \frac{\text{Conc. obtained in injected volume (ppm) X Quantity of final volume (L)}}{\text{Amount of sample taken (kg)}}$$

The calibration curve along with the chromatograms of standard solution of different concentrations of Cypermethrin and Chlorpyrifos are shown in figure 1-5 & figure 6-9, respectively.

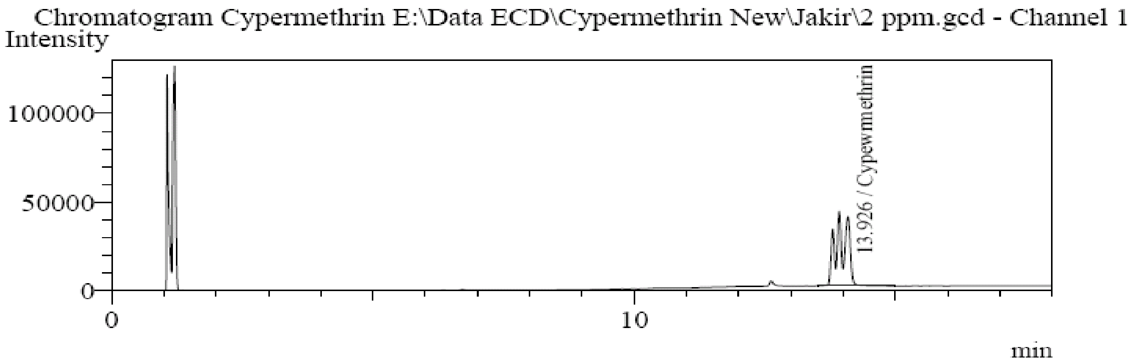


Figure. 1. Chromatogram of 2 ppm standard solution of Cypermethrin

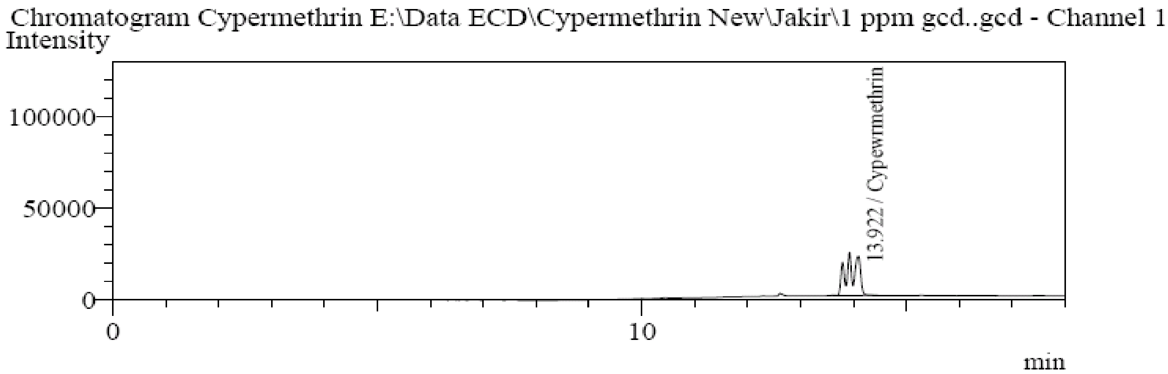


Figure. 2. Chromatogram of 1 ppm standard solution of Cypermethrin

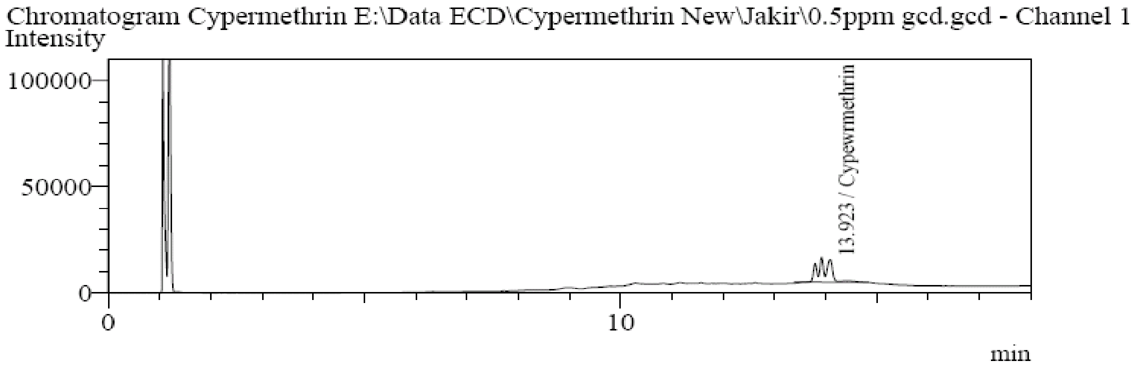


Figure. 3. Chromatogram of 0.5 ppm standard solution of Cypermethrin

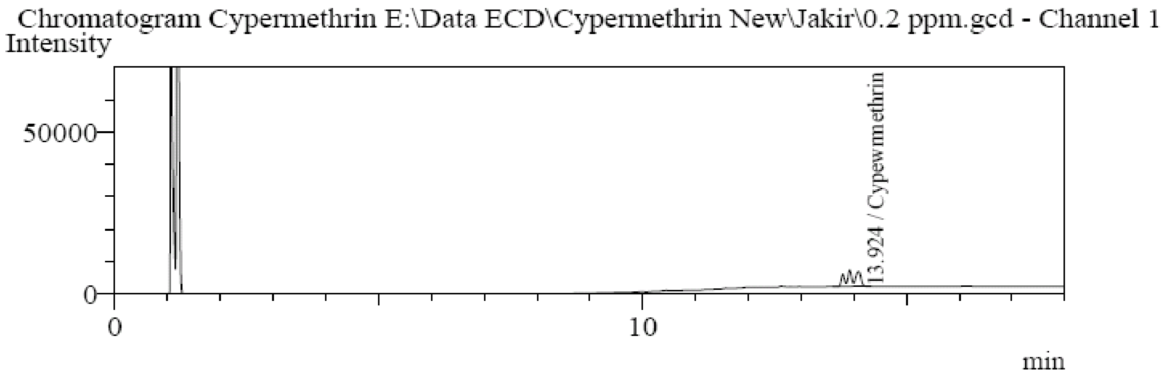
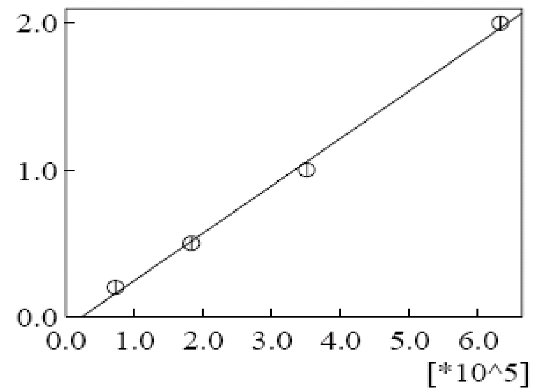


Figure. 4. Chromatogram of 0.2 ppm standard solution of Cypermethrin

Calibration Curve - Analytical Line 2 - Channel 1
ID#:1 Name:Cypewrmethrin

f(x)=3.23504734949e-006*x-7.59224453034e-002
R=0.998317014406 R^2=0.996636861253
MeanRF:2.87815255815e-006 RFSD:1.97972954829e-007 RFRSD:6.87847328551
CurveType:Linear
ZeroThrough:Not through
WeightedRegression:None

External Standard



No.	Conc.	Area
1	2.000	631899
2	1.000	350434
3	0.500	182748
4	0.200	72518

Figure. 5: Calibration curve made with different concentrations of Cypermethrin Standard

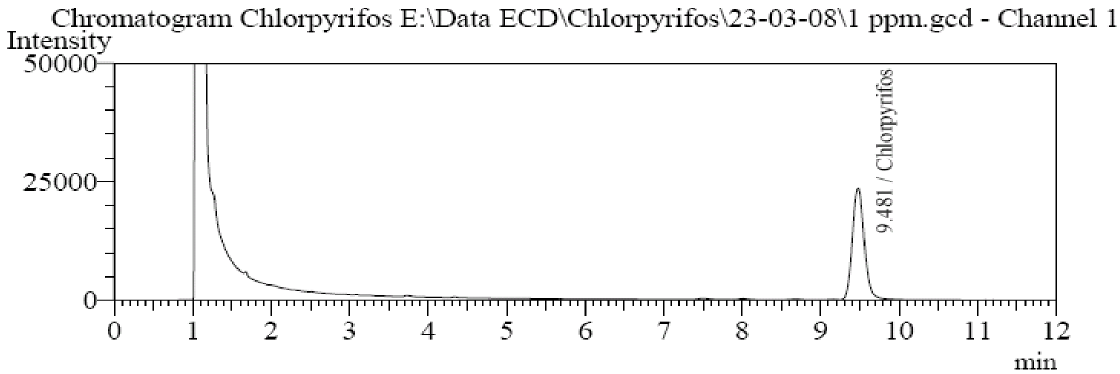


Figure. 6. Chromatogram of 1 ppm standard solution of Chlorpyrifos

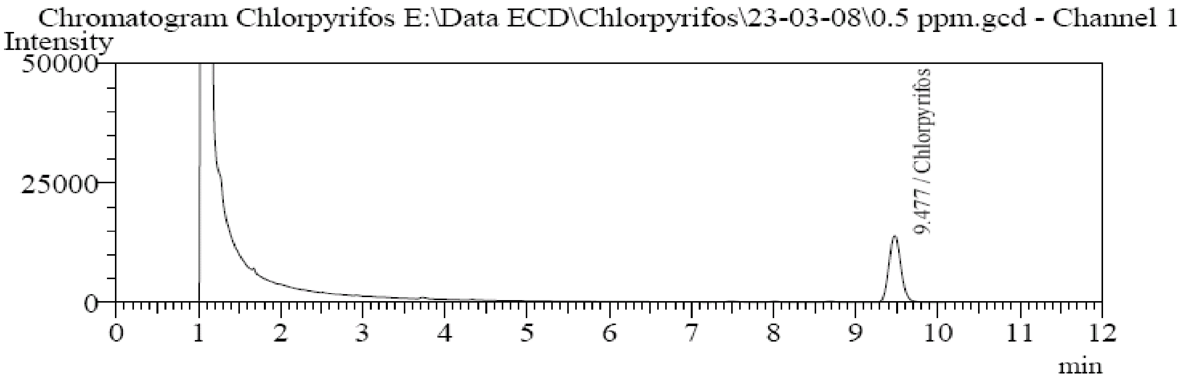


Figure. 7. Chromatogram of 0.5 ppm standard solution of Chlorpyrifos

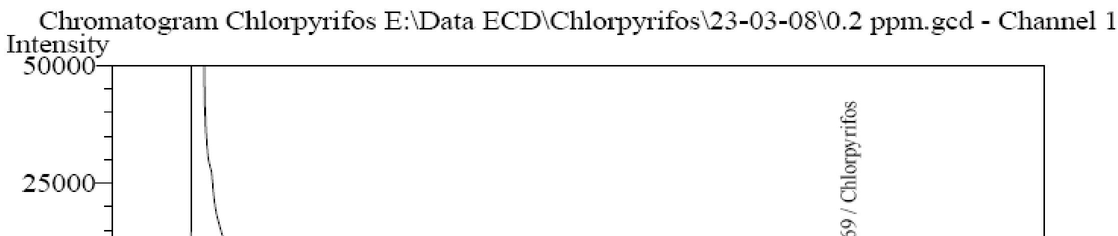
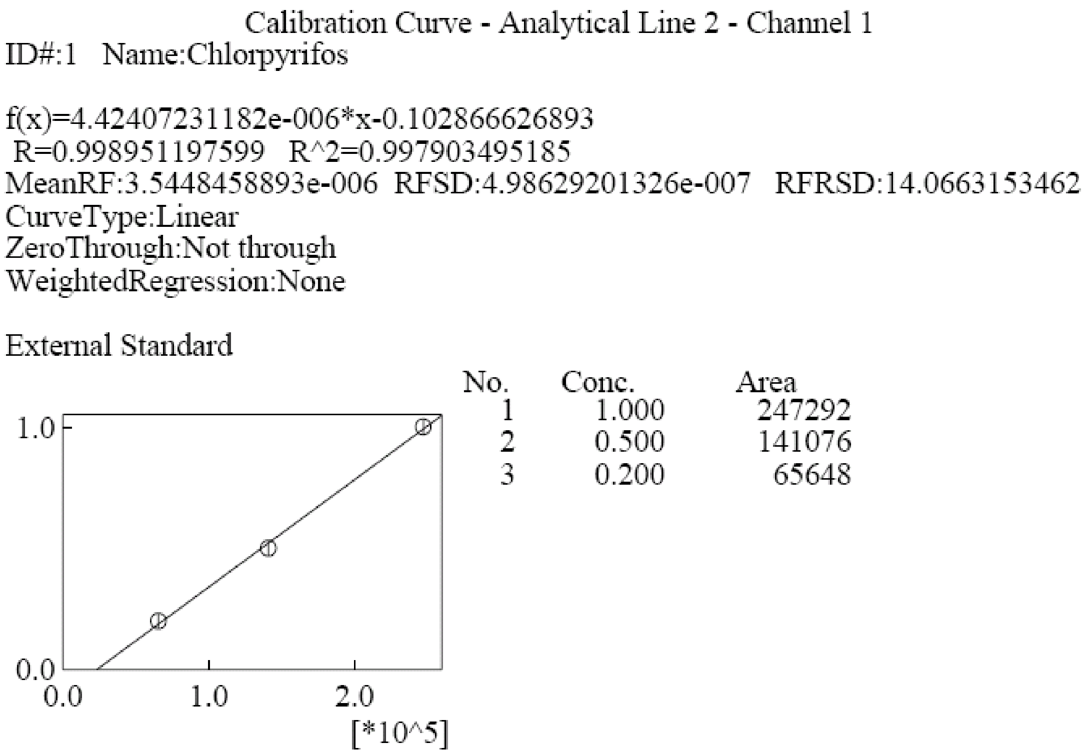


Figure. 8. Chromatogram of 0.2 ppm standard solution of Chlorpyrifos

Figure. 9: Calibration curve made of different concentrations of Chlorpyrifos standard.

Figure. 8. Chromatogram of 0.2 ppm standard solution of Chlorpyrifos



Fig

CHAPTER 4

RESULTS AND DISCUSSION

Experiment 1: Development of management practice against tomato fruit borer, *Helicoverpa armigera* (Hubner)

This experiment was conducted to evaluate some management practices applied against tomato fruit borer, *Helicoverpa armigera* (Hubner) in winter tomato variety BARI-2 (Ratan). The results have been presented and discussed and possible interpretations have been given under the following sub-headings:

4.1 Effect of management practices in controlling tomato fruit borer in terms of number of fruits at different fruiting stage

4.1.1.1 Early stage

Significant variation was observed by number of fruits plant^{-1}, number of infested fruit plant^{-1}, percent fruit infestation and percent (%) reduction over control at early fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 1 and Appendix III.

Among different treatments in the study, the highest number of fruit plant^{-1} (11.07) was recorded in treatment $T_{3,}$ which was not significantly different from T_1 (10.91) but significantly different from all other treatments. On the other hand, the lowest number (8.97) of fruit plant^{-1} was recorded in control treatment T_6 which was not significantly different from T_5 (9.15) and similar with T_2 (9.45). Treatment T_4 showed intermediate result (10.11) which was significantly different from all other treatments. From these results it is revealed that Cypermethrin spraying@ 1-5 ml/l of water gives the better result against tomato fruit borer which was similar of the findings of the experiment of Alam (2004).

The lowest number of infested fruit plant^{-1} (0.13) was recorded in T_3 treatment which was significantly similar with T_1 (0.43) and different from all other treatments (Table 1). On the other hand, the highest number of infested fruit plant^{-1} (1.07) was recorded in control treatment T_6 which was similar with T_5 (0.86). The treatments T_2 (0.72) and T_4 (0.55) showed intermediate level of infestation which was different from all other treatments. In this case, the trend of the number of infested fruits plant^{-1} is $T_6 > T_5 > T_2 > T_4 > T_1 >$ T3.

The lowest percent fruit infestation by number (1.17%) was recorded in T_3 treatment and T_1 (4.27%) and T_4 (5.44%) showed comparatively lower infestation but significantly different from all other treatments. On the other hand, the highest percent fruit infestation by number (11.90%) was recorded in control treatment T_6 and T_2 (7.62%) and T_5 (9.40%) showed comparatively higher infestation but significantly different from all other treatments. Divokar and Power (1987) also reported that spraying of various insecticides such as Cypermethrin (30g a.i./ha), Deltamethrin (l0g a.i./ha) and cypermethrin (100g a.i./ha) gave good control of *Helicoverpa. Armigera.*

It was observed in figure 10 that the highest % reduction over control (90.18%) was in the treatment T_3 which was significantly different from all other treatments. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (21.14%). Intermediate level of % reduction over control was observed in the treatment T_4 and T_1 and range from (54.36-66.95).

Table 1. Effect of different control measures in controlling tomato fruit borer at early stage in terms of number of fruits plant^{-1}

Treatments	Early stage		
	Total	Infested	% infestation
T_1	10.91 a	0.43 bc	4.27 d
T_2	9.45 bc	0.72 ac	7.62 c
T_3	11.07 a	0.13 c	1.17 e
T_4	10.11 b	0.55 ac	5.44 d
T_5	9.15 c	0.86 ab	9.40 b
T_6	8.97 c	1.07 a	11.90 a
LSD $_{0.05}$	0.6904	0.581	1.468
CV (%)	6.58	8.79	5.25

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.1.2 Mid stage

Significant variation was observed by number of fruits plant^{-1},number of infested fruit plant^{-1},percent fruit infestation and percent (%) reduction over control at mid fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 2 and Appendix III.

The highest number of fruit plant^{-1} (11.77) was recorded in treatment T_3 which was followed by T1 (11.46) and identical with T_2 (10.41) and T_4 (10.79). On the other hand, the lowest number (9.27) of fruit plant^{-1} was recorded in control treatment T_6 which was not significantly different from T_5 (9.63). The trend of the number of infested fruit is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The lowest number of infested fruit plant^{-1} (0.35) was recorded in T_3 treatment which was not significantly different from T_1 (0.41) and different from all other treatments (Table 2). On the other hand, the highest number of infested fruit plant^{-1} (1.18) was recorded in control treatment T_6 which was not significantly different from T_5 (1.06) and similar with T_2 (0.84) and T_4 (0.56). Divokar and Power (1987) also reported that spraying of various insecticides such as Cypermethrin (30g a.i./ha), Deltamethrin (l0g a.i./ha) and permethrin (100g a.i./ha) gave good control of *Helicoverpa. Armigera.*

The lowest percent fruit infestation by number (2.97%) was recorded in T_3 treatment which was not significantly different from T_1 (3.58%) but significantly different from all other treatments. On the other hand, the highest percent fruit infestation in number (12.70%) was recorded in control treatment T_6 and T_2 (8.07%) and T_5 (11.00%) showed comparatively higher infestation but significantly different from all other treatments. The treatment T_4 (5.19%) showed intermediate result. In these cases, the trend of percent infestation of fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_6 > T_5 > T_2 > T_4 > T_1 > T_3$ (Table 2).

It was observed in figure 10 that the highest % reduction over control (76.67%) was observed in the treatment T_3 which was not significantly different from T_1 (71.88%) but significantly different from all other treatments. On the other hand, the lowest

% reduction over control was observed in the treatment T_5 (13.59%). which was significantly different from all other treatments. The treatment T_2 (36.61%) and T_4 (59.23%) showed intermediate result.

Table 2. Effect of different control measures in controlling tomato fruit borer at mid stage in terms of number of fruits plant^{-1}

Treatments	Mid stage		
	Total	Infested	% infestation
T_1	11.46 a	0.41 b	3.58 e
T_2	10.41 ab	0.84 ab	8.07 c
T_3	11.77 a	0.35 b	2.97 e
T_4	10.79 ab	0.56 ab	5.19 d
T_5	9.63 b	1.06 a	11.00 b
T_6	9.27 b	1.18 a	12.70 a
$LSD_{0.05}$	1.688	0.5782	1.580
CV (%)	7.88	9.14	10.56

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.1.3 Late stage

Significant variation was observed by number of fruits plant^{-1}, number of infested fruit plant^{-1}, percent fruit infestation and percent (%) reduction over control at late fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 3 and Appendix III.

Among different treatments in the study the highest number of fruit plant^{-1} (12.47) was recorded in treatment T_3 which was similar with T_1 (11.68), T_2 (11.37) and T_4 (11.47). On the other hand, the lowest number (9.57) of fruit plant^{-1} was recorded in control treatment T_6 which was not significantly different from T_5 (10.11). From these results it is revealed that the trend of the number of fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The lowest number of infested fruit plant^{-1} (0.45) was recorded in T_3 treatment which was significantly similar with T_1 (0.62) and different from all other treatments (Table 1). On the other hand, the highest number of infested fruit plant^{-1} (1.30) was recorded in control treatment T_6 which was significantly similar with T_2 (1.12) and T_5 (1.22). Treatment T_4 (0.85) showed intermediate result compared to other treatments.

The lowest percent fruit infestation by number (3.63%) was recorded in T_3 treatment which was significantly similar with T_1 (5.16%) but significantly different from all other treatments (Table 1). On the other hand, the highest percent fruit infestation in number (13.60%) was recorded in control treatment T_6 which was significantly similar with T_5 (12.10%). The treatment T_2 (9.85%) and T_4 (7.41%) showed intermediate result.

It was observed from the figure 10 (Ten) that the highest % reduction over control (73.27%) was observed in the treatment T_3 and treatment T_1 (62.00%). On the other hand, the lowest % reduction over control was observed in the treatment T_5 (13.59%) and treatment T_2 (27.47%) showed comparatively lower % reduction over control compared to other treatments. The treatment T_4 (45.43%) showed intermediate level of reduction over control. Karim (1994) also stated that, weekly spray application of the extract of neem seed kernel has been found to be effective against *Helicoverpa armigera*

Table 3. Effect of different control measures in controlling tomato fruit borer at late cropping stage in terms of number of fruits plant^{-1}

Treatments	Late stage		
	Total	Infested	% infestation
T_1	11.68 ab	0.62 bc	5.16 de
T_2	11.37 ab	1.12 ab	9.85 bc
T_3	12.47 a	0.45 c	3.63 e
T_4	11.47 ab	0.85 ac	7.41 cd
T_5	10.11 b	1.22 ab	12.10 ab
T_6	9.57 b	1.30 a	13.60 a
$LSD_{0.05}$	1.984	0.592	2.758
CV (%)	5.58	4.45	8.87

In the column,numeric data represents the mean value of 3 replications;each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

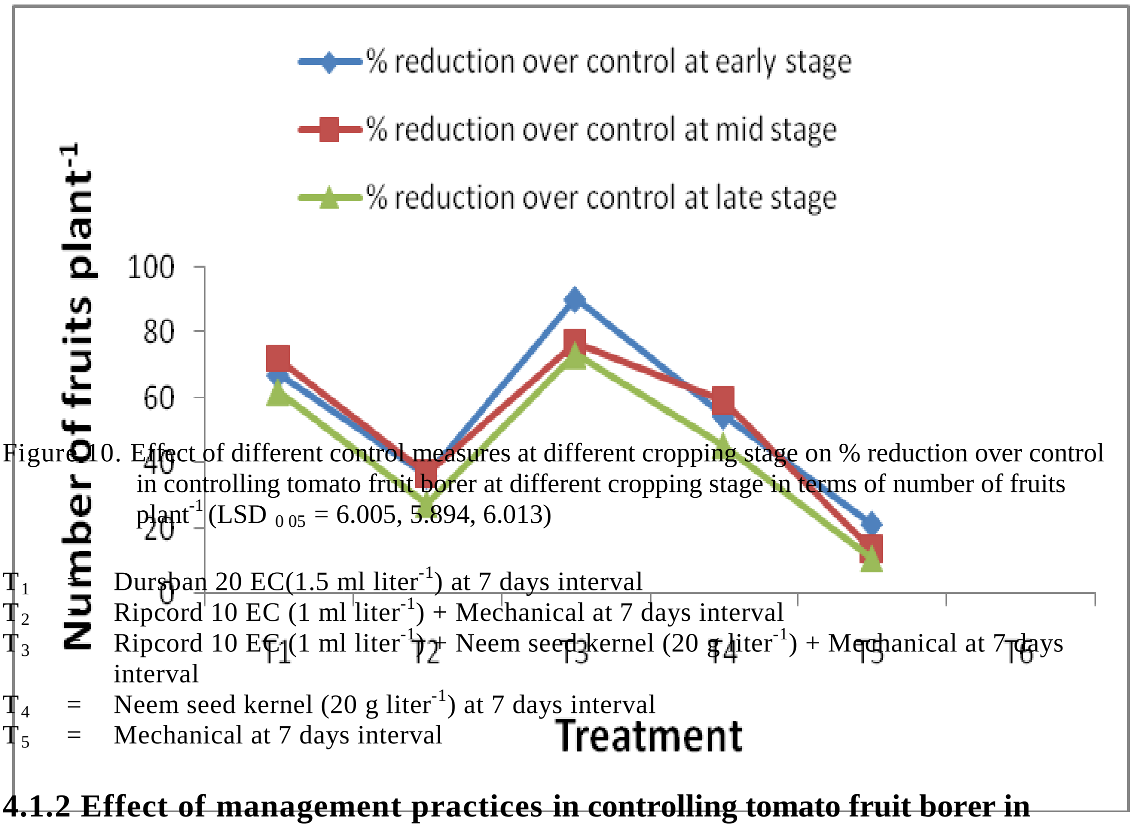


Figure 10. Effect of different control measures at different cropping stage on % reduction over control in controlling tomato fruit borer at different cropping stage in terms of number of fruits plant^{-1} (LSD $_{0.05}$ = 6.005, 5.894, 6.013)

T_1	=	Dursban 20 EC(1.5 ml liter^{-1}) at 7 days interval
T_2	=	Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3	=	Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4	=	Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5	=	Mechanical at 7 days interval

4.1.2 Effect of management practices in controlling tomato fruit borer in terms of weight of fruits at different fruiting stage

4.1.2.1 Early stage

Significant variation was observed by weight of total fruits plant^{-1}, weight of infested fruit plant^{-1}, percent fruit infestation and percent (%) reduction over control at early fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 4 and Appendix IV.

Table 4 represented that the highest weight of fruit plant^{-1} (1059.40 g) was recorded in treatment T_3 which was significantly different from all other treatments but treatment T_1 (1007.73 g) showed comparatively higher fruit weight. On the other hand, the lowest weight (764.51 g) of fruit plant^{-1} was recorded in control treatment T_6 which was also significantly different from all other treatments but treatment T_2 (849.70 g) and T_5 (804.01 g) showed comparatively lower fruit weight. Treatment T_4 (925.77 g) showed intermediate result which was significantly different from all other treatments. From these results it is revealed that the trend of the weight of fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The lowest weight of infested fruit plant^{-1} (12.44 g) was recorded in T_3 treatment which was significantly different from all other treatments (Table 4). On the other hand, the highest weight of infested fruit plant^{-1} (91.20 g) was recorded in control treatment T_6 which was significantly different from all other treatments but treatment T_2 (64.74 g) and T_5 (75.57 g) showed comparatively higher infested fruit weight. The treatments T_1 (39.70 g) and T_4 (50.36 g) showed intermediate levels of infested fruit weight which was significantly different from all other treatments. In this case, the trend of the weight of infested fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_6 > T_5 > T_2 > T_4 > T_1 > T_3$. .

The lowest percent infested fruit weight (1.18%) was recorded in T_3 treatment and T_1 (3.94%) and T_4 (5.41%) showed comparatively lower infestation but significantly different from all other treatments (Table 4). On the other hand, the highest percent weight of fruit infestation (11.88%) was recorded in control treatment T_6 and T_2 (7.64%) and T_5 (9.42%) showed comparatively higher infestation but significantly different from all other treatments.

As shown in figure 11 that the highest % reduction over control (90.15%) was observed in the treatment T_3 which was significantly different from all other treatments. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (21.11%) which was significantly different from all other treatments. The treatment T_1 (66.91%) and T_4 (54.38%) showed intermediate result but significantly different from all other treatments Ogunwolu(1989) Cypermethrin suppressed fruit damage by 70.4 and 52.2% in 1985 and 1986 and increased yield by 115.0 and 67.6%, respectively.

Table 4. Effect of different control measures in controlling tomato fruit borer at Early cropping stage in terms of fruit weight plant^{-1}

Treatments	Early stage		
	Total	Infested	% infestation
T_1	1007.73 b	39.70 e	3.94 e
T_2	849.70 d	64.74 c	7.64 c
T_3	1059.40 a	12.44 f	1.18 f
T_4	925.77 c	50.36 d	5.41 d
T_5	804.01 e	75.57 b	9.42 b

T_6	764.51 f	91.20 a	11.88 a
LSD $_{0.05}$	13.71	4.836	0.765
CV (%)	7.21	8.63	7.41

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.2.2 Mid stage

Significant variation was observed by weight of total fruits plant^{-1}, weight of infested fruit plant^{-1}, percent fruit infestation and percent (%) reduction over control at mid fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 5 and Appendix IV.

Table 5 represented that the highest weight of fruit plant^{-1} (1126.39 g) was recorded in treatment T_3 which was significantly different from all other treatments but treatment T_1 (1058.10 g) showed comparatively higher fruit weight. On the other hand, the lowest weight (790.01 g) of fruit plant^{-1} was recorded in control treatment T_6 which was also significantly different from all other treatments but treatment T_5 (846.19 g) showed comparatively lower fruit weight. Treatment T_2 (933.96 g) and T_4 (988.04g) showed intermediate result which was significantly different from all other treatments.

The lowest weight of infested fruit plant^{-1} (33.50 g) was recorded in T_3 treatment which was not significantly different from T_1 (37.86 g) (Table 4). On the other hand, the highest weight of infested fruit plant^{-1} (100.60 g) was recorded in control treatment T_6 which was significantly different from all other treatments but treatment T_2 (75.52 g) and T_5 (93.14 g) showed comparatively higher infested fruit weight. The treatments T_4 (51.29 g) showed intermediate levels of infested fruit weight which was significantly different from all other treatments. In this case, the trend of the weight of infested fruits plant^{-1} is $T_6 > T_5 > T_2 > T_4 > T_1 >$ T3.

The lowest percent infested fruit weight (2.93%) was recorded in T_3 treatment which was significantly similar with T_1 (3.61%) and T_4 (5.22%) showed comparatively lower percent infestation but significantly different from all other treatments (Table 5). On the other hand, the highest percent weight of fruit infestation (12.60%) was recorded in control treatment T_6 which was not significantly different from T_5 (11.08%) and T_2 (8.03%) showed comparatively higher infestation but significantly different from all other treatments.

Figure 11 showed that the highest % reduction over control (76.83%) was observed in the treatment T_3 which was not significantly different from T_1 (71.77%) treatments. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (13.51%) which was significantly different from all other treatments. The treatment T_2 (36.69%) and T_4 (59.14%) showed intermediate result but significantly different from all other treatments. In these cases, the trend of percent infestation of fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5$.

Table 5. Effect of different control measures in controlling tomato fruit borer at Mid cropping stage in terms of fruit weight plant^{-1}

Treatments	Mid stage		
	Total	Infested	% infestation
T_1	1058.10 b	37.86 e	3.61 cd
T_2	933.96 d	75.52 c	8.03 b
T_3	1126.39 a	33.50 e	2.93 d
T_4	988.04 c	51.29 d	5.22 c
T_5	846.19 e	93.14 b	11.08 a
T_6	790.08 f	100.60 a	12.60 a
$LSD_{0.05}$	47.58	6.411	1.899
CV (%)	10.44	6.69	8.82

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.2.3 Late stage

Significant variation was observed by weight of total fruits plant^{-1}, weight of infested fruit plant^{-1}, percent fruit infestation and percent (%) reduction over control at late fruiting stage in controlling tomato fruit borer for different control measures under the present trial presented in Table 6 and Appendix IV.

Table 6 represented that the highest weight of fruit plant^{-1} (1193.38 g) was recorded in treatment T_3 which was significantly different from all other treatments but treatment T_1 (1108.89 g), T_2 (1022.28 g) and T_4 (1050.31 g) showed comparatively higher fruit weight. On the other hand, the lowest weight (815.65 g) of fruit plant^{-1} was recorded in control treatment T_6 which was also significantly different from all other treatments but treatment T_5 (888.36 g) showed comparatively lower fruit weight. From these results it is revealed that the trend of the weight of fruits plant^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The lowest weight of infested fruit plant^{-1} (43.07 g) was recorded in T_3 treatment which was significantly different from all other treatment but the treatment T_1 (57.24 g) showed comparatively lower weight of infested fruit (Table 6). On the other hand, the highest weight of infested fruit plant^{-1} (110.80 g) was recorded in control treatment T_6 which was not significantly different from T_5 (107.20 g) and significantly similar with T_2 (100.7 g). The treatments T_4 (77.83 g) showed intermediate levels of infested fruit weight which was significantly different from all other treatments. .Divokar and Power (1987) Gopal and Senquttuvan (1997) reported the similar results earlier from their experiments.

The lowest percent infested fruit weight (3.58%) was recorded in T_3 treatment which was significantly different from all other treatments but treatment T_1 (5.20%) showed comparatively lower percent infestation (Table 6). On the other hand, the highest percent weight of fruit infestation (13.54%) was recorded in control treatment T_6 which was not significantly different from T_5 (12.15%) and T_2 (9.80%) showed comparatively higher percent infestation but significantly different from all other treatments. Treatment T_4 (7.44%) showed intermediate result.

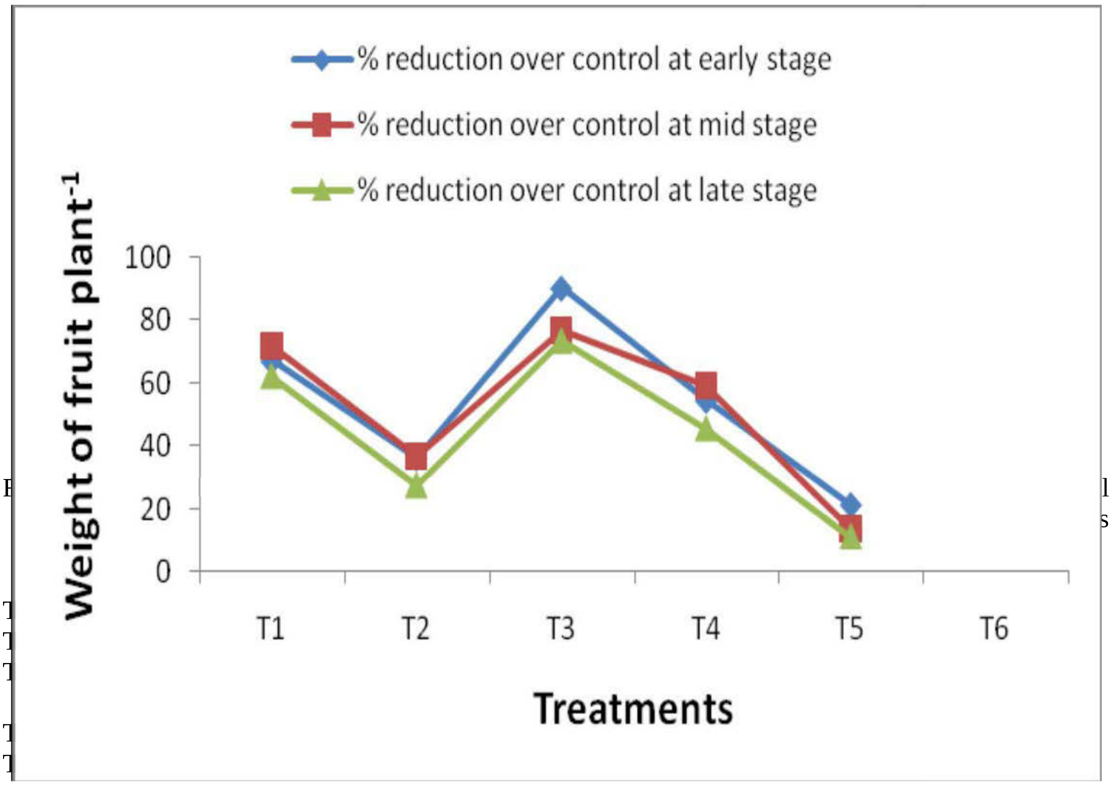
Figure 11 showed that the highest % reduction over control (73.42%) was observed in the treatment T_3 which was significantly different from all other treatment but treatment T_1 (62.12%) showed comparatively higher % reduction over control. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (11.11%) which was significantly different from all other treatments but treatment T_2 (27.39%) showed comparatively lower % reduction over control. The treatment T_4 (45.50%) showed intermediate result but significantly different from all other treatments. Ogunwolu (1989) Cypermethrin suppressed fruit damage by 70.4 and 52.2% in 1985 and 1986 and increased yield by 115.0 and 67.6%, respectively.

Table 6 Effect of different control measures in controlling tomato fruit borer at Late cropping stage in terms of fruit weight plant^{-1}

Treatments	Late stage		
	Total	Infested	% infestation
T_1	1108.89 b	57.24 d	5.20 d
T_2	1022.28 c	100.7 ab	9.80 b
T_3	1193.38 a	43.07 e	3.58 d
T_4	1050.31 c	77.83 c	7.44 c
T_5	888.36 d	107.2 a	12.15 a
T_6	815.65 e	110.8 a	13.54 a
$LSD_{0.05}$	42.80	10.07	1.822
CV (%)	7.95	9.11	11.27

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control



4.1.3 Effect of control options against tomato fruit borer during cropping Season

4.1.3.1 Tomato fruit plant^{-1} by number

Significant variation was observed on total tomato fruit, infested fruit, percent infestation and % reduction of tomato fruit plant^{-1} by number in controlling tomato fruit borer for different control measures under the present trial presented in Table 7 and Appendix V.

Table 7 represented that the highest tomato fruit plant^{-1} by number (36.24) was recorded in treatment T_3 which was significantly similar with T_1 (35.84). On the other hand, the lowest tomato fruit plant^{-1} by number (31.36) was recorded in control treatment T_6 which was significantly similar with T_5 (32.03). The treatment T_2 (33.91) and T_4 (34.33) showed intermediate result compared to other treatments.

The lowest infested tomato fruit plant^{-1} by number (0.92) was recorded in treatment T_3 which was not significantly different from T_1 (1.46) and significantly similar with T_4 (1.96) (Table 3). On the other hand, the highest infested tomato fruit plant^{-1} by number (3.55) was recorded in T_6 treatment which was not significantly different from T_5 (3.14) and significantly similar with T_2 (2.68). In this case, the trend of the infested fruits plant^{-1} by number was observed due to application of the different management practices against tomato fruit borer is $T_6 > T_5 > T_2 > T_4 > T_1 > T_3$.

The lowest percent infested fruit plant^{-1} by number (2.57%) was recorded in T_3 treatment which was significantly similar with T_1 (4.07%) treatments (Table 3). On the other hand, the highest percent infested fruit plant^{-1} by number (11.30%) was recorded in control treatment T_6 which was significantly similar with T_5 (9.80%). The result obtained from T_2 (7.90%) and T_4 (5.71%) showed intermediate result compared to other treatments.

Figure 12 showed that the highest % reduction over control (77.30%) was observed in the treatment T_3 which was significantly different from all other treatment but treatment T_1 (64.05%) showed comparatively higher % reduction over control. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (13.43%) which was significantly different from all other treatments but treatment T_2 (30.21%) showed comparatively lower % reduction over control. The treatment T_4 (49.56%) showed intermediate result but significantly different from all other treatments. In these cases, the trend of % reduction over control was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5$.

Table 7 Effect of different control measures in controlling tomato fruit borer during total cropping season in terms of fruit by number

Treatments	Tomato fruit plant^{-1} by number			
	Total	Healthy	Infested	% infestation
T_1	35.84 ab	34.38 ab	1.46 c	4.07 cd
T_2	33.91 ac	31.26 bc	2.68 ab	7.90 b
T_3	36.24 a	35.32 a	0.92 c	2.57 d
T_4	34.33 ac	32.37 b	1.96 bc	5.71 c
T_5	32.03 bc	28.89 d	3.14 a	9.80 ab
T_6	31.36 c	27.81 de	3.55 a	11.30 a
LSD $_{0.05}$	3.593	1.156	1.005	2.156
CV (%)	8.81	7.59	7.39	7.96

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.3.2 Tomato fruit plant^{-1} by weight

Significant variation was observed by weight of total fruit plant^{-1}, weight of infested fruit plant^{-1}, percent fruit infestation by weight and percent reduction over control in controlling tomato fruit borer for different control measures under the present trial presented in Table 8 and Appendix V.

Table 8 represented that the highest tomato fruit plant^{-1} by weight (3470.00 g) was recorded in treatment T_3 which was significantly different from all other treatments but T_1 (3300.00 g) showed higher tomato fruit plant^{-1} by weight. On the other hand, the lowest tomato fruit plant^{-1} by weight (2670.00 g) was recorded in control treatment T_6 which was also significantly different from all other treatments but T_5 (2810.000 g) showed lower tomato fruit plant^{-1} by weight. The treatment T_2 (3050.00 g) and T_4 (3140.00 g) showed intermediate result compared to other treatments. From these results it is revealed that the trend of the tomato fruits plant^{-1} by weight was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 >$

T_6.

The lowest infested tomato fruit plant^{-1} by weight (90.00 g) was recorded in treatment T_3 which was significantly different from all other treatments (Table 8). On the other hand, the highest infested tomato fruit plant^{-1} by weight (30.00 g) was recorded in T_6 treatment which was not significantly different from T_5 (280.00 g) and the treatment T_2 (240.00 g) showed comparatively higher infested tomato fruit plant^{-1} by weight. The result obtained from T_1 (130.00 g) and T_4 (180.00 g) showed intermediate result compared to other treatments.

The lowest percent infested fruit plant^{-1} by weight (2.59%) was recorded in T_3 treatment which was significantly similar with T_1 (3.94%) treatments (Table 8). On the other hand, the highest percent infested fruit plant^{-1} by weight (11.23%) was recorded in control treatment T_6 which was significantly similar with T_5 (9.96%). The result obtained from T_2 (7.86%) and T_4 (5.73%) showed intermediate result compared to other treatments.

Figure 12 showed that the highest % reduction over control (76.96%) was observed in the treatment T_3 which was significantly different from all other treatment but treatment T_1 (64.95%) showed comparatively higher % reduction over control. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (11.39%) which was significantly different from all other treatments but treatment T_2 (30.07%) showed comparatively lower % reduction over control. The treatment T_4 (49.02%) showed intermediate result but significantly different from all other treatments. In these cases, the trend of % reduction over control was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5$.

Table 8. Effect of different control measures in controlling tomato fruit borer during total cropping season in terms of fruit by weight

Treatments	Tomato fruit plant^{-1} by weight (g)			
	Total	Healthy	Infested	% infestation
T_1	3300.00 b	3170.00 b	130.00 d	3.94 de
T_2	3050.00 d	2810.00 d	240.00 b	7.86 b
T_3	3470.00 a	3380.00 a	90.00 e	2.59 e
T_4	3140.00 c	2960.00 c	180.00 c	5.73 c
T_5	2810.00 e	2530.00 e	280.00 a	9.96 ab
T_6	2670.00 f	2370.00 f	300.00 a	11.23 a
LSD $_{0.05}$	63.28	13.59	25.31	1.723
CV (%)	9.19	10.26	7.75	8.04

In the column, numeric data represents the mean value of 3 replications; each replication is derived from 5 plants per treatments.
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

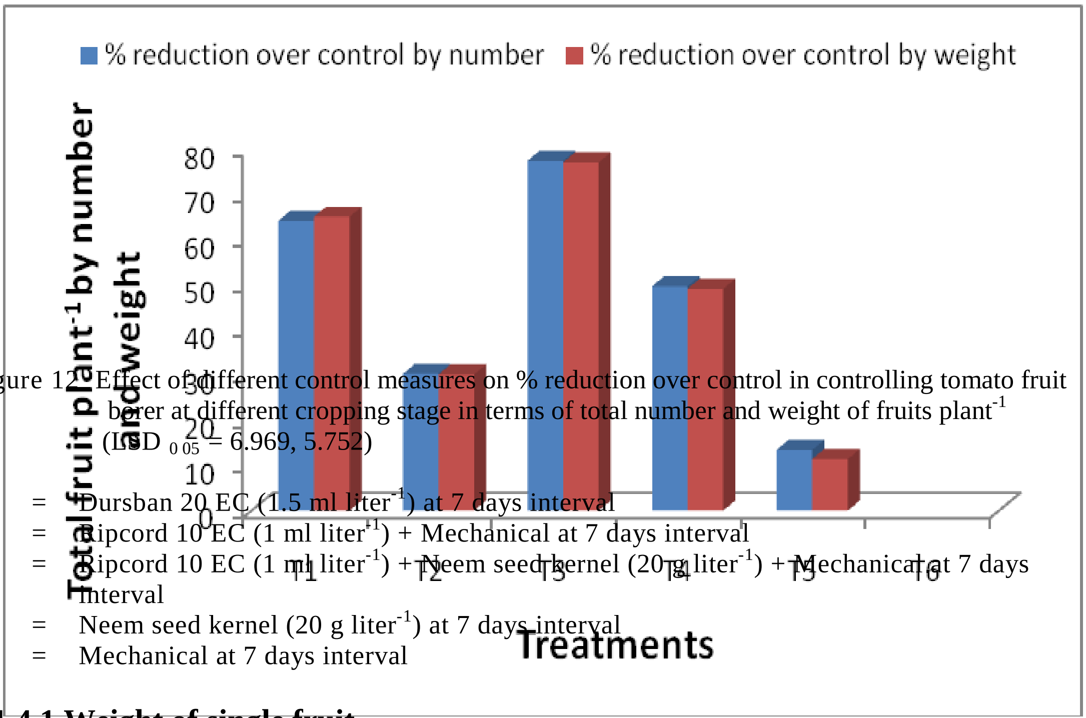


Figure 12. Effect of different control measures on % reduction over control in controlling tomato fruit borer at different cropping stage in terms of total number and weight of fruits plant^{-1} (LSD $_{0.05}$ = 6.969, 5.752)

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval

4.1.4.1 Weight of single fruit

Significant variation was observed in case of weight of single fruit under the present study (Table 4 and Appendix VI). The highest weight of single fruit (95.70 g) was recorded in treatment T_3 which was significantly similar with T_1 (92.33 g) and T_4 (91.57 g). On the other hand, the lowest weight of single fruit (85.23 g) was recorded in control treatment T_6 which was significantly similar with T_5 (87.87 g). The result obtained from the treatment T_2 (89.91 g) showed intermediate result compared to other treatments. From these results it is revealed that the trend of the weight of single fruit was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

4.1.4.2 Fruit weight plot^{-1}

Significant variation was observed in case of total fruit weight plot^{-1}, weight of infested fruit plot^{-1}, percent infestation and percent (%) reduction over control under the present study (Table 4 and Appendix VI).

Table 4 represented that the highest total fruit weight plot^{-1} (52.97 kg) was recorded in treatment T_3 which was not significantly different from T_1 (50.46 kg) and significantly similar with T_4 (48.19 kg). On the other hand, the lowest total fruit weight plot^{-1} (40.95 kg) was recorded in control treatment T_6 which was significantly similar with T_5 (43.13 kg). The result obtained from the treatment T_2 (46.86 kg) showed intermediate result compared to other treatments. From these results it is revealed that the trend of the total fruit weight plot^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The lowest total infested fruit weight plot^{-1} (1.35 kg) was recorded in treatment T_3 which was significantly similar with T_1 (1.97 kg) (Table 4). On the other hand, the highest total infested fruit weight plot^{-1} (4.76 kg) was recorded in control treatment T_6 which was not significantly different from T_5 (4.47 kg) and the treatment T_2 (3.877 kg) showed significantly similar result. The result obtained from T_4 (2.97 kg) showed intermediate result compared to other treatments. In this case, the trend of the total infested fruit weight plot^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_6 > T_5 > T_2 > T_4 > T_1 > T_3$.

The lowest percent infested fruit weight plot^{-1} (2.54%) was recorded in T_3 treatment which was not significantly different from T_1 (3.89%) treatments (Table 4). On the other hand, the highest percent infested fruit weight plot^{-1} (11.60%) was recorded in control treatment T_6 which was not significantly different from T_5 (10.37%). The result obtained from T_2 (8.25%) and T_4 (6.16%) showed intermediate result compared to other treatments. In these cases, the trend of percent infested fruit weight plot^{-1} was observed due to application of the different management practices against tomato fruit borer is $T_6 > T_5 > T_2 > T_4 > T_1 > T_3$.

Figure 13 showed that the highest % reduction over control (78.14%) was observed in the treatment T_3 which was significantly different from all other treatment but treatment T_1 (66.52%) showed comparatively higher % reduction over control. On the other hand, the lowest % reduction over control was observed in the treatment T_5 (10.84%) which was also significantly different from all other treatments but treatment T_2 (29.00%) showed comparatively lower % reduction over control. The treatment T_4 (47.50%) showed intermediate result but significantly different from all other treatments.

Table 9. Effect of different control measure in controlling tomato fruit borer during total cropping season in terms of weight of single fruit and weight of fruit plot^{-1}

Treatments	Weight of single fruit (g)	Tomato fruit weight plot^{-1} (kg)		
		Total	Infested	% infestation
T_1	92.33 ab	50.46 a	1.97 cd	3.89 d
T_2	89.91 a-c	46.86 a-c	3.87 ab	8.25 c
T_3	95.70 a	52.97 a	1.35 d	2.54 d
T_4	91.57 ab	48.19 ab	2.97 bc	6.16 b
T_5	87.87 bc	43.13 bc	4.47 a	10.37 a
T_6	85.23 c	40.95 c	4.76 a	11.60 a
$LSD_{0.05}$	5.886	5.997	1.152	1.344
CV (%)	7.54	6.98	8.18	6.63

In the column,numeric data represents the mean value of 3 replications;each replication is derived from 5 plants per treatments

In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

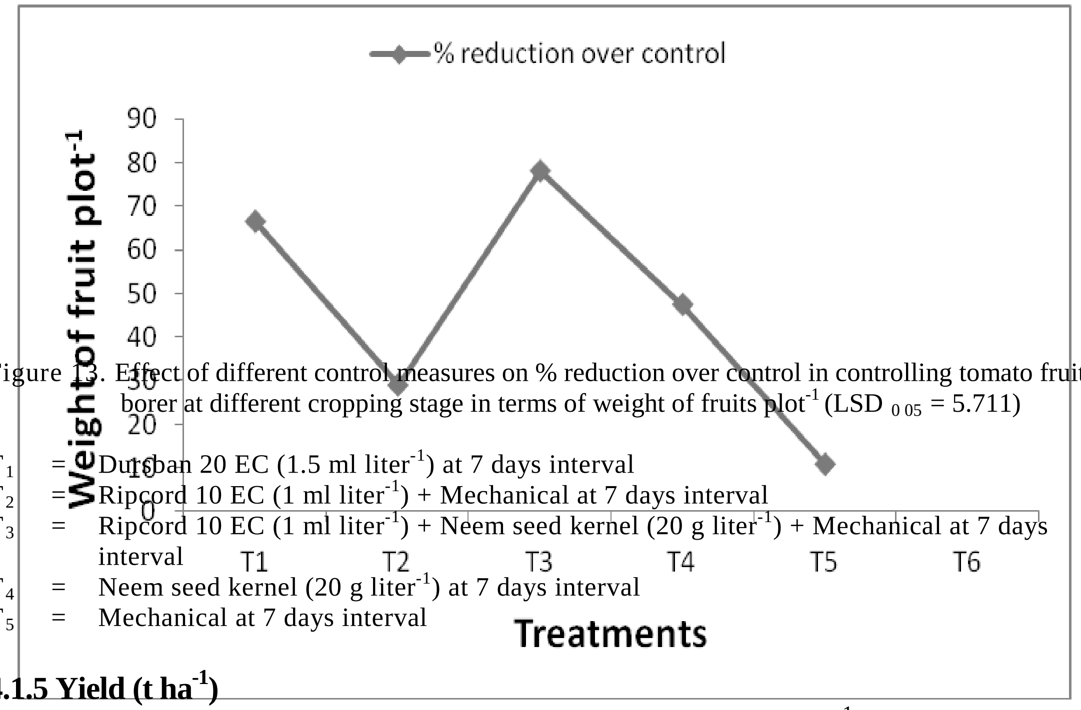


Figure 13. Effect of different control measures on % reduction over control in controlling tomato fruit borer at different cropping stage in terms of weight of fruits plot^{-1} (LSD $_{0.05}$ = 5.711)

T_1 = Dursban 20 EC (1.5 ml liter^{-1}) at 7 days interval
T_2 = Ripcord 10 EC (1 ml liter^{-1}) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g liter^{-1}) at 7 days interval
T_5 = Mechanical at 7 days interval

4.1.5 Yield (t ha^{-1})

Significant variation was observed in case of total yield (t ha^{-1}), healthy fruit yield (t ha^{-1}) and infested fruit yield (t ha^{-1}) under the present study (Table 10 and Appendix VII).

The highest fruit yield (84.41 t ha^{-1}) was recorded in treatment T_3 which was followed the treatment T_1 (79.45 t ha^{-1}).The treatment T_4 (74.22 t ha^{-1}) and T_2 gave the intermediate results compare the other treatments.. On the other hand, the lowest total yield (59.47 t ha^{-1}) was recorded in control treatment T_6 which was statistically identical with T_5 (63.46 t ha^{-1}). From these results it is revealed that the trend of the total yield (t ha^{-1}) was observed due to application of the different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

The highest healthy fruit yield (82.22 t ha^{-1}) was recorded in treatment T_3 which was significantly different from all other treatment but the treatment T_1 (76.33 t ha^{-1}) showed higher healthy fruit yield (Table 5). On the other hand, the lowest healthy fruit yield (52.79 t ha^{-1}) was recorded in control treatment T_6 which was not significantly different from T_5 (57.14 t ha^{-1}). The result obtained from the treatment T_2 (64.86 t ha^{-1}) and T_4 (69.96 t ha^{-1}) showed intermediate result compared to other treatments.

The lowest infested fruit yield (2.19 t ha^{-1}) was recorded in treatment T_3 which was significantly similar with T_1 (3.13 t ha^{-1}) (Table 10). On the other hand, the highest infested fruit yield (6.68 t ha^{-1}) was recorded in treatment T_6 which was not significantly different from T_2 (5.54 t ha^{-1}) and T_5 (6.32 t ha^{-1}). The result obtained from the treatment T_4 (4.25 t ha^{-1}) showed intermediate result compared to other treatments. From these results it is revealed that the trend of the infested fruit yield (t ha^{-1}) was observed in different management practices against tomato fruit borer is $T_3 > T_1 > T_4 > T_2 > T_5 > T_6$.

So, the results of present study gave performance which was more or less similar with researcher's findings of Gopal (1997), Kulat *et al.* (2001) and Sundarajan (2002).

Table 10. Effect of different control measure in controlling tomato fruit borer during total cropping season in terms of yield

Treatments	Yield (t ha^{-1})		
	Total	Healthy	Infested
T_1	79.45 b	76.33 b	3.13 bc
T_2	70.40 c	64.86 d	5.54 a
T_3	84.41 a	82.22 a	2.19 c
T_4	74.22 c	69.96 c	4.25 b
T_5	63.46 d	57.14 e	6.32 a
T_6	59.47 d	52.79 e	6.68 a
$LSD_{0.05}$	4.305	4.444	1.127
CV (%)	7.14	8.51	7.67

In the column,numeric data represents the mean value of 3 replications;each replication is derived from 5 plants per treatments

In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml $liter^{-1}$) at 7 days interval
T_2 = Ripcord 10 EC (1 ml $liter^{-1}$) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml $liter^{-1}$) + Neem seed kernel (20 g $liter^{-1}$) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g $liter^{-1}$) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

4.1.6 Economic analysis

4.1.6.1 Cost of pest management (Tk ha^{-1})

It was observed that the highest cost of pest management (49000.00 Tk. ha^{-1}) was recorded in treatment T_3 which was significantly different from all other treatment. On the other hand, the lowest cost of pest management (20000.00 Tk ha^{-1}) was recorded in treatment T_5 which was also significantly different from all other treatments. The pest management cost obtained from the treatment T_1 (41000.00 Tk ha^{-1}), T_2 (42000.00 Tk ha^{-1}) and T_4 (38000.00 Tk ha^{-1}) was less than T_3 and very much higher than T_5 and significantly different(Table-11)

4.1.6.2 Gross return (Tk ha^{-1})

Table 11 showed that the highest gross return (833150.00 Tk. ha^{-1}) was recorded in treatment T_3 which was significantly different from all other treatment. On the other hand, the lowest gross return (561300.00 Tk. ha^{-1}) was recorded in control treatment T_6 which was also significantly different from all other treatments. The gross return obtained from the treatment T_1 (778950.00 Tk ha^{-1}), T_2 (676300.00 Tk ha^{-1}), T_4 (720850.00) and T_5 (603000.00 Tk ha^{-1}) was less than T_3 and higher than control treatment T_6 and significantly different.

4.1.6.3 Net returns (Tk ha^{-1})

As shown in Table 11, the highest net return (784150.00 Tk. ha^{-1}) was recorded in treatment T_3 which was significantly different from all other treatment. On the other hand, the lowest net return (561300.00 Tk. ha^{-1}) was recorded in control treatment T_6 which was also significantly different from all other treatments. The net return obtained from the treatment T_1 (737950.00 Tk. ha^{-1}), T_2 (634300.00 Tk. ha^{-1}), T_4 (682850.00) and T_5 (583000.00 Tk. ha^{-1}) was less than T_3 and higher than control treatment T_6 and significantly different.

4.1.6.4 Adjusted net return (Tk ha^{-1})

From the Table 11, it was observed that the highest adjusted net return (222850.00Tk. ha^{-1}) was recorded in treatment T_3 which was significantly different from all other treatment. On the other hand, the lowest adjusted net return (21700.00Tk. ha^{-1}) was recorded in treatment T_5 which was also significantly different from all other treatments. The adjusted net return obtained from the treatment T_1 (176650.00 Tk. ha^{-1}), T_2 (73000.00 Tk. ha^{-1}) and T_4 (121550.00 Tk. ha^{-1}) was less than T_3 and higher than treatment T_5 and significantly different.

4.1.6.5 Benefit: cost ratio (BCR)

Considering the control of tomato fruit borer, the highest benefit cost ratio (4.55) was obtained from the treatment T_3 followed by treatment T_1 (4.30) and T_4 (3.19). On the other hand, the lowest benefit cost ratio (1.08) was obtained from the treatment T_5 followed by treatment T_2 (1.73) (Table-11). Petel *et al*. (1991) stated that the highest cost-benefit ratio (1: 5.26) followed by endosulfan (2%) dust (1: 4.9). Results are also given for monocrotophos, quinalphos and malathion.

Table11. Economic analysis for different control measures applied against tomato fruit borer

Treatments	Cost of pest management (Tk ha^{-1})	Gross return (Tk ha^{-1})	Net return (Tk ha^{-1})	Adjusted net return (Tk ha^{-1})	Benefit : cost ratio (BCR)
T_1	41000.00 c	778950.00 b	737950.00 b	176650.00 b	4.30 ab
T_2	42000.00 b	676300.00 d	634300.00 d	73000.00 d	1.73 c
T_3	49000.00 a	833150.00 a	784150.00 a	222850.00 a	4.55 a
T_4	38000.00 d	720850.00 c	682850.00 c	121550.00 c	3.19 b
T_5	20000.00 e	603000.00 e	583000.00 e	21700.00 e	1.08 d
T_6	--	561300.00 f	561300.00 f	--	--
$LSD_{0.05}$	64.95	118.90	113.60	206.30	0.2413
CV (%)	10.88	11.45	9.94	11.28	7.28

Market price of tomato: Tk 10.00/kg for healthy and Tk 5.00/kg for infested fruit
In the column,numeric data represents the mean value of 3 replications;each replication is derived from 5 plants per treatments
In the column means having similar letter(s) are statistically identical and those having dissimilar letter(s) differ significantly as per 0.05 level of probability.

T_1 = Dursban 20 EC (1.5 ml $liter^{-1}$) at 7 days interval
T_2 = Ripcord 10 EC (1 ml $liter^{-1}$) + Mechanical at 7 days interval
T_3 = Ripcord 10 EC (1 ml $liter^{-1}$) + Neem seed kernel (20 g $liter^{-1}$) + Mechanical at 7 days interval
T_4 = Neem seed kernel (20 g $liter^{-1}$) at 7 days interval
T_5 = Mechanical at 7 days interval
T_6 = Control

Experiment 2: Quantification of residue of cypermethrin and chlorpyrifos in Tomato fruit

4.2.1 Determination of Residue

The concentrated extracts of tomato fruit samples of different days after spraying (DAS) were subjected to analysis by GC-2010 with the pre-set parameters. Appendix 8-16 show the chromatograms of the injected extracts of tomato fruit samples containing Cypermethrin and Chlorpyrifos residues at different DAS.

The results of the analysis of Cypermethrin residue in tomato fruit sample are summarized in the Table 12

Table 12: Quantity of residue of Cypermethrin estimated from tomato fruit

Days after Spraying	Application rate (ml/L of water)	Sample weight (g)	Total volume prepared (ml)	Injected volume (µl)	Concent. obtained in final volume (ppm)	Residue of Cypermethrin left (ppm)

0	1	20	10	1	5.151	2.575
1	1	20	10	1	3.923	1.961
3	1	20	10	1	1.523	0.762
5	1	20	10	1	0.062	0.031

From the table 12, it was observed that Cypermethrin residue was detected in the sample up to 5 DAS and the quantities were over MRL up to 3 DAS. At 0 DAS the residue in the sample was 2.575 ppm which degrades to 1.961 ppm at 1 DAS and 0.762 ppm at 3 DAS. At 5 DAS it was 0.031 ppm which was below the MRL. The present results more or less agree with the observation of Khan *et al* (2005), they observed that the initial residue of Cypermethrin on tomato fruits were found to be 0.87 mg/Kg which were reduced to 0.10 mg/Kg after 15 Days.

The results of the analysis of Chlorpyrifos residue in tomato fruit sample are summarized in the Table 13.

Table13: Quantity of residue of Chlorpyrifos estimated from tomato fruit

Days after Spraying	Application rate (ml/L of water)	Sample weight (g)	Total volume prepared (ml)	Injected volume (µl)	Concent. obtained in final volume (ppm)	Residue of Chlorpyrifos left (ppm)
0	1.5	20	10	1	4.014	2.007
1	1.5	20	10	1	3.078	1.539
3	1.5	20	10	1	2.280	1.140
5	1.5	20	10	1	1.216	0.608
7	1.5	20	10	1	0.536	0.268

FAO/WHO Codex Alimentarius Commission Recommended

MRL of Cypermethrin in tomato: 0.5 mg/kg crop

ADI of Cypermethrin in tomato: 0.5mg/kg body weight (Anon.1993)

MRL of Chlorpyrifos in tomato: 0.5mg/kg crop

ADI of Chlorpyrifos in tomato: 0.01mg/kg body weight (Anon.1993)

In the current study, the left over residue of Chlorpyrifos in tomato fruit had been detected up to 7 DAS, of which up to 5 DAS the quantity of residue were above MRL. At 0 DAS the residue was 2.007 ppm and they were 1.539 ppm, 1.140 ppm and 0.608 ppm at 1 DAS, 3 DAS and 5 DAS, respectively. All these quantities were above MRL. At 7 DAS it was 0.268 ppm which was below the MRL. The present results more or less agree with the observation of Khan, *et al* (2005), he observed that the initial residue of Chlorpyrifos on apple fruits were found to be 2.70 mg/Kg which were reduced to 0.10 mg/Kg after 21 Days. In another study by

Anonymous (1989), they observed that Chlorpyrifos residues in tomatoes harvested at early, mid and late seasons were determined 0.27 ppm, 0.25 ppm and 0.18 ppm, respectively. These reside levels in tomatoes were below the international MRL established by Codex Alimentarious Commission.

4.2.2 Trend of Degradation

The trends of degradation of Cypermethrin and Chlorpyrifos residues in tomato fruit are shown in Fig. 14 and 15.

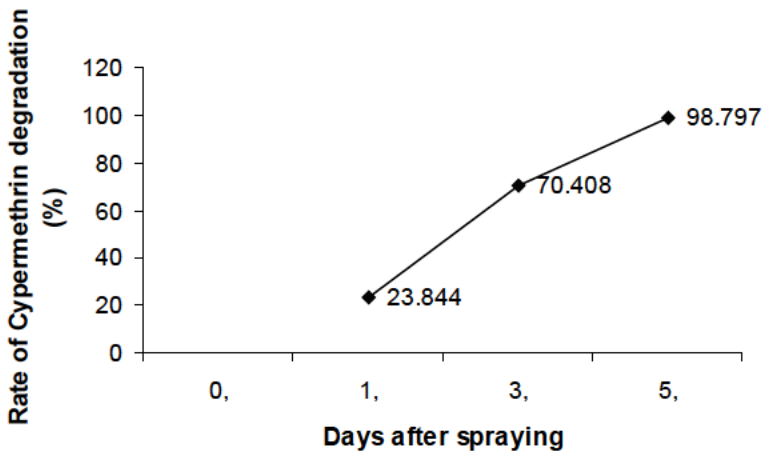


Fig 14 :The trend of Cypermethrin degradation in tomato fruit

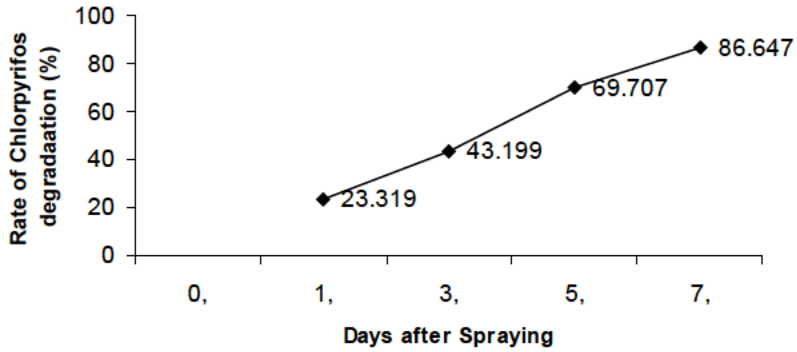


Fig 15: The trend of Chlorpyrifos degradation in tomato fruit

Figure 14 shows that Cypermethrin residue in tomato fruit degraded faster. Degradation was found to be 23.844 % at 1 DAS, which went up to 70.408 % at 3 DAS and 98.797 % at 5 DAS. Figure 15 shows that Chlorpyrifos residue in tomato fruit degraded gradually up to 5 DAS (23.319-69.707) and it was found to be 86.647 % at 7 DAS.

CHAPTER 5

SUMMARY AND CONCLUSION

Tomato fruit borer is one of the most harmful insect in our country. This is mostly control by the chemical insecticides, which are available in the market. But the present investigation was undertaken for the development of management practice against tomato fruit borer and qualification of residue of cypermethrin and chlorpyrifos. The experiment included six treatments (i) Dursban (1.5 ml liter^{-1}) at 7 days interval, (ii) Ripcord (1.0 ml liter^{-1}) + Mechanical at 7 days interval, (iii) Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval, (iv) Neem seed kernel (20 g liter^{-1}) at 7 days interval, (v) Mechanical at 7 days interval and (vi) Control with three replications. Data on number of total fruits and infested fruits plant^{-1}, weight of fruit plant^{-1} and plot^{-1}, number of cluster plant^{-1}, number of fruit cluster^{-1}, weight of single fruit and finally yield (t ha^{-1}) were recorded and at last economic analysis was done and the recorded data were analyzed statistically.

From the recording of data it was observed that the highest number of fruit plant^{-1} at early, mid and late stage were 11.07, 11.77 and 12.47 respectively and similarly the lowest percent infestation was 1.17%, 2.97% and 3.63% respectively were with the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval. The percent reduction over control 90.19%, 76.67% and 73.27% respectively at early, mid and late stage was the highest with the same treatment.

The data obtained from the different it was observed that the highest weight of fruit plant^{-1} at early, mid and late stage were 1059.40g, 1126.39g and 1193.38g respectively and similarly the lowest percent infestation was 1.18%, 2.93% and 3.58% respectively were with the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval. The percent reduction over control 90.15%, 76.83% and 73.42% respectively at early, mid and late stage was the highest with the same treatment.

It was also observed that total tomato fruit plant^{-1} by number and weight was also highest with the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval. The highest total tomato fruit plant^{-1} by number (36.24), by weight (3470g) and the lowest percent infestation by number (2.57%), by weight (2.59%) and highest percent reduction over control by number and weight 77.30% and 76.96% respectively were obtained with the same treatment.

Incase of the highest number of cluster plant^{-1} (11.53), number of fruit cluster^{-1} (3.06) and weight of single fruit (95.70g) were achieved with the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval although number of cluster plant^{-1} and number of fruit cluster^{-1} had no significant effect. The highest healthy fruit yield (82.22 t ha^{-1}) and the lowest infested fruit yield (2.19 t ha^{-1}) and as a result of total fruit yield (84.41 t ha^{-1}) was also obtained from the same treatment.

Economic analysis also represented that the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval had the best performance on gross return, net return, adjusted net return and benefit cost ratio. It was observed that the highest on gross return (833150.00Tk. ha^{-1}), net return (784150.00Tk. ha^{-1}), adjusted net return (222850.00Tk. ha^{-1}) and benefit cost ratio (4.55) was obtained with the same treatment.

The Tomato growers of Bangladesh use insecticides more frequently. Improper application along with impurity of marketed insecticides is suspected for control failure and repeated use of insecticides. The purity of pesticide and residue analysis in our country is still at initial stage because of lack of awareness, economic support and well equipped laboratory. In recent years, pesticide analytical and residue research gained momentum in Bangladesh. Pesticide Analytical Laboratory of BARI attained ability of detecting 0.5-1.0 ppb concentration of several pesticides which makes MRL (Maximum Residue Limit) and ADI (Acceptable Daily Intake) research feasible in Bangladesh. From the above findings it can be concluded that the treatment of Ripcord (1.0 ml liter^{-1}) + Neem seed kernel (20 g liter^{-1}) + Mechanical at 7 days interval had the best performance compared to the other treatment and this treatment can be recommended for further trial in different Agro-ecological Zones (AEZ)..

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APPENDICES

Appendices I. Monthly average of air temperature, relative humidity and total rainfall of the experimental site during the period from December 2007 to May 2008

Month	Year	Monthly average air temperature (^0C)			Average relative humidity (%)	Total rainfall (mm)	Total sunshine (hours)
		Maximum	Minimum	Mean			
November	2007	34.00	29.30	31.65	63.28	476	949.00
December	2007	34.80	30.80	32.80	70.00	288	1302.00
January	2008	24.31	13.65	18.978	72.90	159	1455.00
February	2008	25.92	14.11	20.015	62.78	170	1827.50
March	2008	31.59	22.15	26.867	59.13	258	1821.00
April	2008	34.37	26.06	30.218	61.51	180	2546.00
May	2008	34.78	24.57	29.675	64.23	616	2359.00

Source: Bangladesh Meteorological Department, Agargaon, Dhaka

Appendix II. Physical characteristics and chemical composition of soil of the experimental plot.

Soil Characteristics	Analytical results
Agrological Zone	Madhupur Tract
P^H	6.00 – 6.63
Organic matter	0.84
Total N (%)	0.46
Available phosphorous	21 ppm
Exchangeable K	0.41 meq / 100 g soil

Source: Soil Resource and Development Institute (SRDI), Dhaka.

Appendix III. Effect of different control measures in controlling tomato fruit borer at different cropping stage in terms of number of fruits plant^{-1}

Source of variance	Degrees of freedom	Early stage				Mid stage				Late stage			
		Total	Infested	% infestation	% reduction over control	Total	Infested	% infestation	% reduction over control	Total	Infested	% infestation	% reduction over control
Replication	2	0.030	0.003	0.184	0.194	0.711	0.020	1.279	1.800	0.389	0.001	2.509	7.200
Treatment	5	2.43*	0.33**	43.92*	258.31*	2.93**	1.80**	48.28**	275.59*	3.44**	0.35**	46.06*	197.54*
Error	10	4.144	0.102	6.651	10.172	0.861	0.007	0.754	9.800	1.189	0.006	2.299	10.200

Appendix IV. Effect of different control measures in controlling tomato fruit borer at different cropping stage in terms of fruit weight plant^{-1}

Source of variance	Early stage				Mid stage				Late stage			
	Total	Infested	% infestation	% reduction over control	Total	Infested	% infestation	% reduction over control	Total	Infested	% infestation	% reduction over control
Replication	24.042	42.667	0.141	7.20	126.50	0.21	0.017	0.012	581.657	0.167	0.06	16.60
Treatment	4065.09*	233.64*	44.92**	215.04*	4827.86*	245.22*	47.74**	286.20*	5783.51*	237.75*	46.18**	909.90*
Error	56.832	7.067	0.177	13.70	68.90	12.418	1.090	14.50	553.522	7.767	1.003	17.60

Appendix V. Effect of different control measures in controlling tomato fruit borer during total cropping season in terms of fruit number and weight

Source of variance	Degrees of freedom	Tomato fruit plant^{-1} by number				Tomato fruit plant^{-1} by weight (g)			
		Total	Infested	% infestation	% reduction over control	Total	Infested	% infestation	% reduction over control
Replication	2	1.50	0.004	0.003	1.800	0.018	0.000	0.121	0.800
Treatment	5	11.61*	3.08**	34.16**	196.12*	0.267**	0.021**	34.66**	208.91*
Error	10	3.900	0.305	1.405	9.30	0.121	0.101	0.158	9.30

Appendix VI. Effect of different control measure in controlling tomato fruit borer during total cropping season in terms of number of cluster plant^{-1}, number of fruit cluster^{-1}, weight of single fruit and weight of fruit plot^{-1}

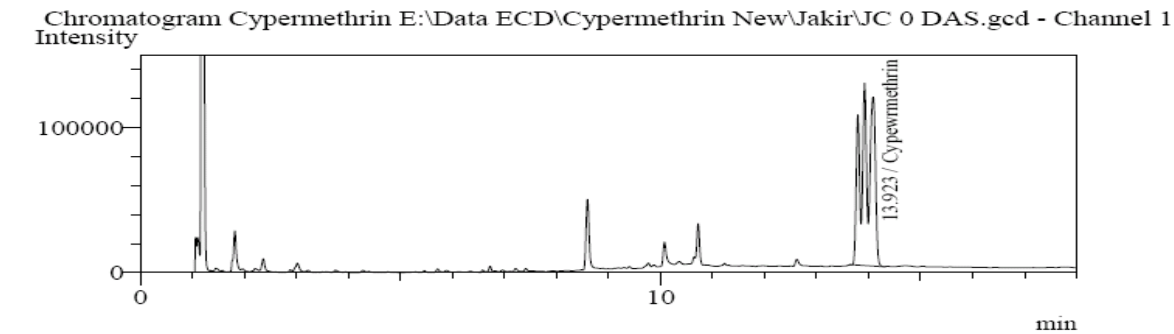
Treatments	Number of cluster plant^{-1}	Number of fruit cluster^{-1}	Weight of single fruit (g)	Tomato fruit weight plot^{-1} (kg)			
				Total	Infested	% infestation	% reduction over control
Replication	0.443	0.002	0.667	2.667	0.000	0.002	0.200
Treatment	1.026^{NS}	0.041^{NS}	39.928	60.35*	5.69**	44.34**	235.54*
Error	1.929	0.103	10.467	11.867	0.401	0.546	9.20

Appendix VII. Effect of different control measure in controlling tomato fruit borer during total cropping season in terms of yield

Treatments	Degrees of freedom	Yield (t ha^{-1})			Benefit cost ratio (BCR)
		Total	Healthy	Infested	
Replication	2	10.245	13.167	0.211	0.062
Treatment	5	268.12*	378.54*	9.73**	7.07**
Error	10	5.60	5.97	0.38	0.116

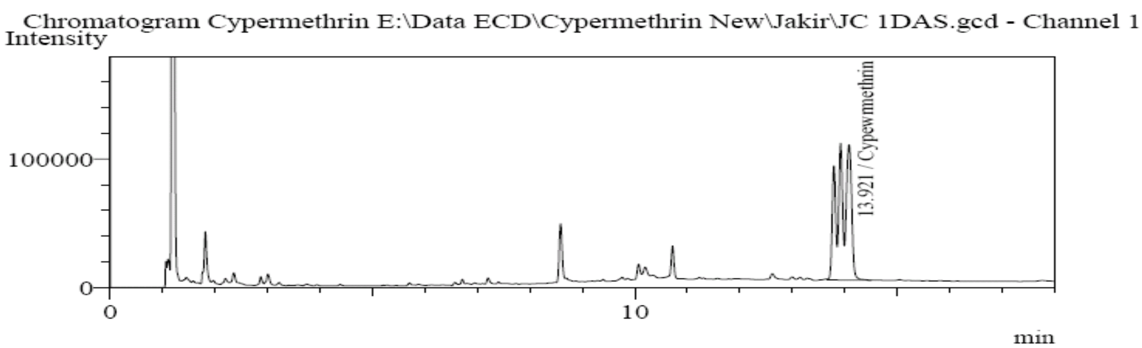
Appendix VIII: Chromatogram of Cypermethrin obtained from the extract of tomato fruit

collected from tomato field at 0 (6 hour) DAS.



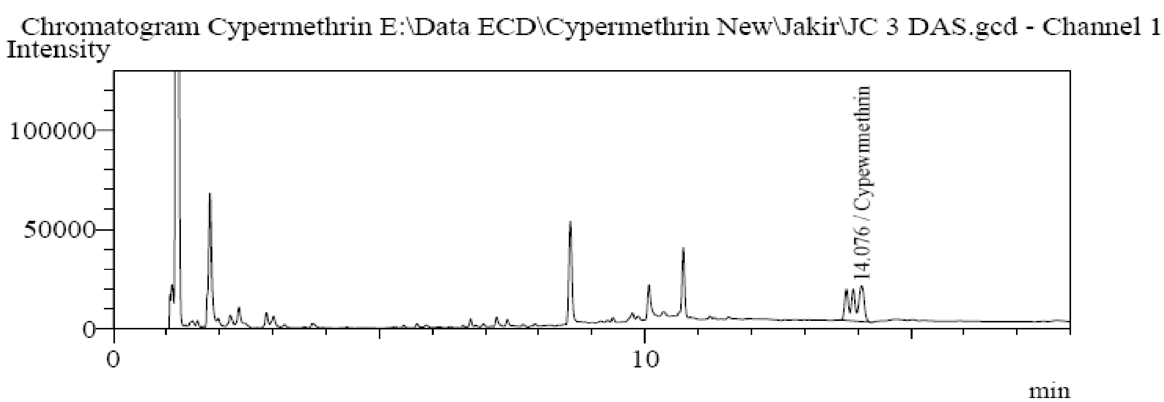
Appendix IX: Chromatogram of Cypermethrin obtained from the extract of tomato fruit

collected from tomato field at 1 DAS.

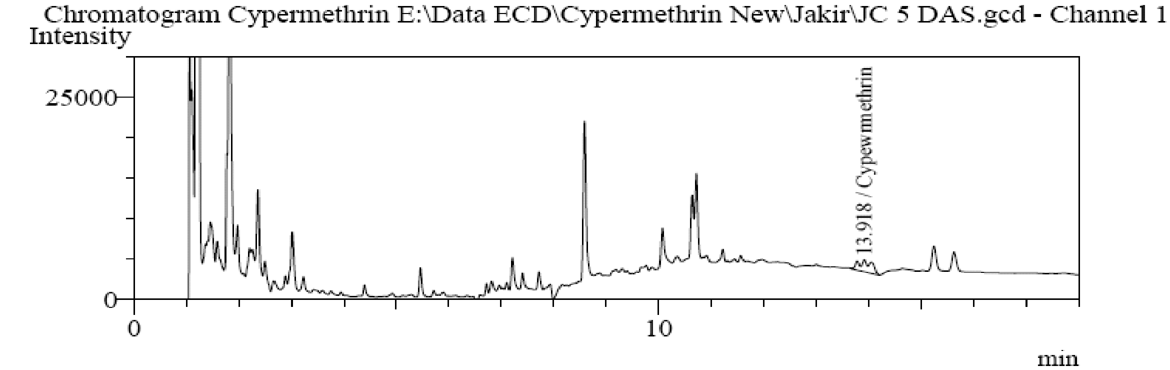


Appendix X: Chromatogram of Cypermethrin obtained from the extract of tomato fruit

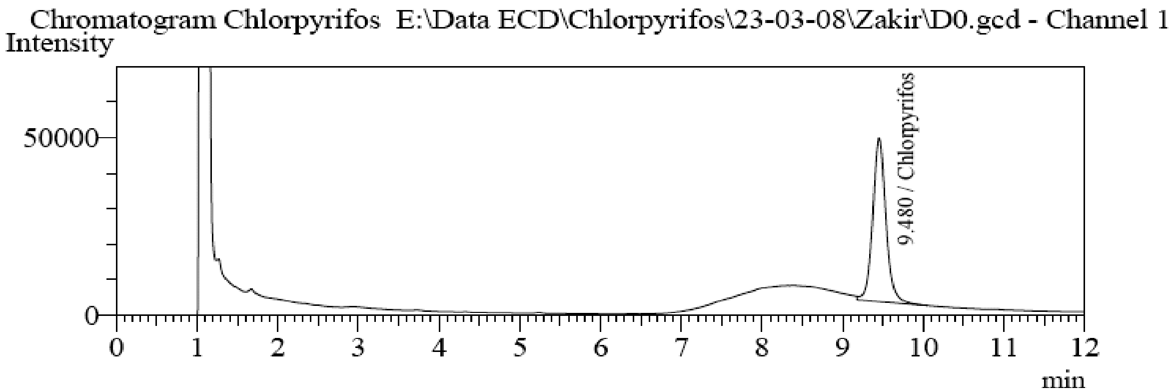
collected from tomato field at 3 DAS.



Appendix XI: Chromatogram of Cypermethrin obtained from the extract of tomato fruit collected from tomato field at 5 DAS.

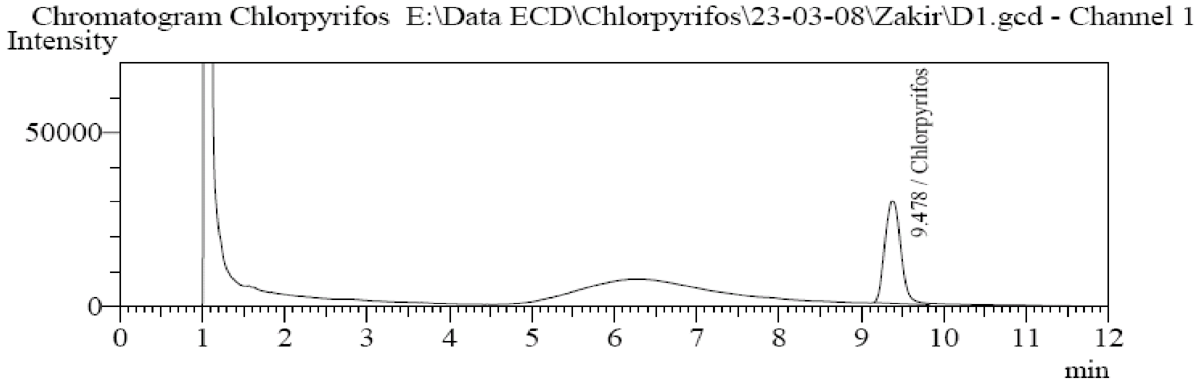


Appendix XII: Chromatogram of Chlorpyrifos obtained from the extract of tomato fruit collected from tomato field at 0 (6 hour) DAS



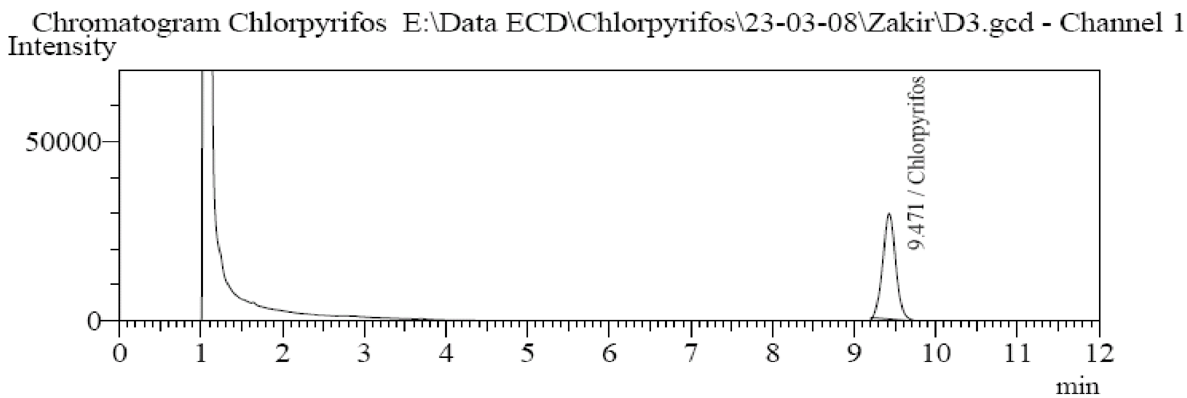
Appendix XIII: Chromatogram of Chlorpyrifos obtained from the extract of tomato fruit

collected from tomato field at 1 DAS.



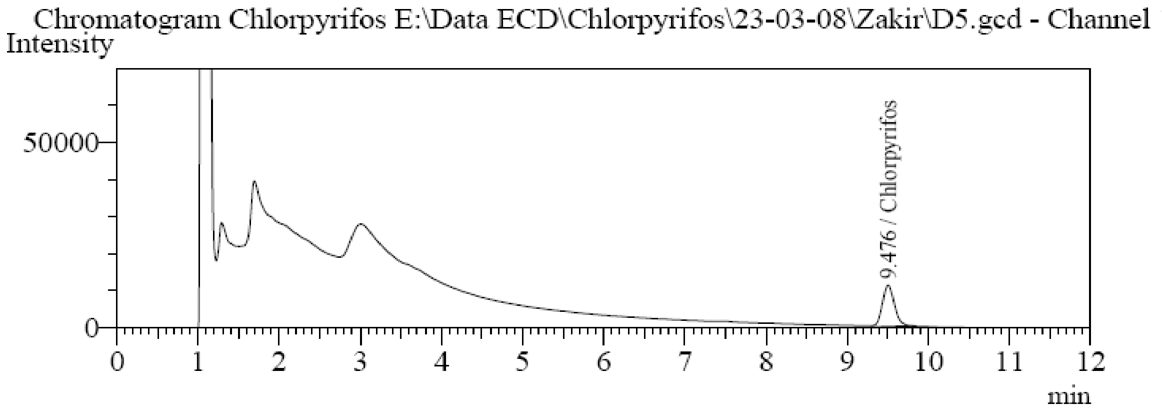
Appendix XIV: Chromatogram of Chlorpyrifos obtained from the extract of tomato fruit

collected from tomato field at 3 DAS



Appendix XV: Chromatogram of Chlorpyrifos obtained from the extract of tomato fruit

collected from tomato field at 5 DAS.



Appendix XVI:Chromatogram of Chlorpyrifos obtained from the extract of tomato fruit

collected from tomato field at 7 DAS.